ASSESSMENT OF CORROSION IN OFFSHORE STRUCTURES THROUGH INSPECTION REPORTS AND EXPERIMENTS

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UNIVERSITI TEKNOLOGI PETRONAS

CERTIFICATION OF APPROVAL

Assessment of Corrosion in Offshore Structures through Inspection Reports and Experiments

by

ONG SHIOU TING

A project dissertation submitted to the
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in partial fulfilment of the requirement for the
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Approved by,

Narayan

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JAN 2010

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CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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ONG SHIOU TING

ABSTRACT

Corrosion in Marine and Offshore Structures such as Jacket platforms and jetty piles is one of the issues to be considered during the design and maintenance. The current corrosion allowance in the splash zone for structural element is 12mm (PTS 20.073). Currently, no studies had been done on determining the appropriate corrosion allowance for offshore steel structures in Malaysia. This issue is crucial because many of the around 200 offshore structures in Malaysia are reaching their design life and a lower corrosion allowance would mean that they can be continued to be used without strengthening the structures. There are five zones at the seawater environment which include subsoil, continuously submerged, tidal, splash zone above high tidal and atmospheric zone. The rate of corrosion varies in different zones.

The goal of this project is to define corrosion allowance and evaluate the effectiveness of the cathodic protection and anodes on offshore structural members from PETRONAS inspection reports. This goal is achieved in three stages : collection and analyse the PCSB Underwater Inspection Maintenance data from various platforms, conduct an experiment which involves fabricating of samples of different types of tubular members and immersing the same in different seawater zones at BOUSTEAD shipyard at Lumut. The samples will be inspected periodically and measurements will be taken to determine the nature and rate of corrosion. The results will be compared with the recommended values in the current code.

The implementation of the correct corrosion allowance would benefit PETRONAS in terms of cost reduction and excellent structure integrity in all circumstances. Case study on all the reports for the platform in Sabah showed that data was not available from earlier inspection which could have been missed during platform handover.

ACKNOWLEDGEMENTS

Throughout the Final Year Research Project, numerous amount of guidance, advices, assistance and support had been provided to the author by various individuals/groups all the way.

First of all, the author would like to express his greatest gratitude and heartfelt appreciation AP Dr. Narayanan Sambu Potty for all the support and guidance that has been provided to the author throughout the project. He was indeed a great source of light when she was in the dark. Without him, the author could not have fulfilled her goal to such a great extent.

Sincere thanks to Mr. Ismail Mokhtar and Mr. Mohd Asyraf Bin Abd. Rahim from Boustead Shipyard Sdn.Bhd for approving the location for the experiments and provide assistance during the installation of the set up of the experiment.

Thirdly, the author would like to express his sincerest appreciation to Mr. Jose Ungson, Senior Engineers and Mr. Mohd Rodhi Bakar from PETRONAS CariGali Sdn. Bhd. for their generous assistance in supplying the TYPE 3 mild steel sample (corrosion coupons) needed for the testing. Without the sponsorship of the company, the author could not have advanced to another stage.

The author would also like to thank AP Dr. Mohd Shahir Liew for his kind assistance during the installation of the set up of the experiment and provide guidance to the author throughout the project.

And last but not least, the author's endless gratitude and love goes to beloved parents, family and friends especially Tang Chun Feng, for bestowing endless support, motivation, understanding, and being there when needed most.

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ABBREVIATION & NOMENCLATURES

BAN: Bar Anode

CPS: Cathodic potential measurements

CPSP: Cathodic potential survey positions

FAC: Flow Accelerated Corrosion

MIC: Microbiologically influenced corrosion

MSL: Mean Sea Level

PTS: PETRONAS Technical Standards

ROV: Remote Operated Vehicles

VDM: Diagonal members

VEM: Jacket leg

Anode corrosion efficiency : The ratio of the actual corrosion (weight loss) of an anode to the theoretical corrosion (weight loss) calculated by Faraday's law from the quantity of electricity that has passed.

Cathodic protection : A corrosion control system in which the metal to be protected is made to serve as a cathode, either by the deliberate establishment of a galvanic cell or by impressed current. (See **anodic protection.**)

Cathodic reaction : Electrode reaction equivalent to a transfer of negative charge from the electronic to the ionic conductor. A cathodic reaction is a reduction process.

Corrosion potential : The potential of a corroding surface in an electrolyte relative to that of a reference electrode measured under open-circuit conditions

Corrosion rate : The amount of corrosion occurring per unit time (for example, mass change per unit area per unit time, penetration per unit time).

Corrosivity : The tendency of an environment to cause corrosion in a given corrosion system.

Corrosion : A chemical or electrochemical reaction between a material, usually a metal, and its environment that produces a deterioration of the material and its properties.

localized corrosion : Corrosion at discrete sites; for example, pitting, crevice corrosion, and stress corrosion cracking.

Pitting : Corrosion of a metal surface, confined to a point or small area, that takes the form of cavities.

CHAPTER 1

INTRODUCTION

1.1 Background

Many marine steel structures in Malaysia are aging rapidly. Corrosion is a problem to be considered during design and maintenance. Various corrosion allowances are prescribed for structural members from different standard such as Norsok-M001, American Standard, and Det Norske Veritas. No studies have been reported on determination of appropriate corrosion allowance for offshore steel structures in Malaysia. This issue is of critical importance because many of the about 200 platforms in Malaysia have reached their design life.

The weather environment is classified as severe (eg. The North Sea), moderate (Gulf of Mexico) or mild (eg.Malaysia) with additional cost for corrosion allowance being 9%, 6% and 4% of the total platform cost inclusive of the piling. The reduction in corrosion allowance can signify large savings. Alternatively, structures may still be safe at the end of the design life.

Corrosion of steel in marine environments especially in the submerged zones is mostly electrochemical in nature. In evaluating corrosion of steel structures in marine environment, it is necessary to examine each area/zone of the structure exposed to different environmental conditions. These areas/zones are: atmospheric zone, splash zone and continuous submerged zone. The corrosion rate in each of the zones can vary considerably.

This research focuses on the condition and degree of deterioration of offshore structures based on inspection reports of various platforms obtained from Petronas CariGali Sdn Bhd (PCSB). The method of Cathodic potential and the Percent wastage of Anode are used for the purpose. An experiment which involves fabricating of samples of different types of tubular members and immersing the same in different seawater zones at the BOUSTEAD Shipyard Sdn Bhd at Lumut are conducted.

The corrosion process of steel in marine environments depends on numerous parameters. These parameters can be classified into endogenous parameters related to the steel material, exogenous parameters related to the environment and a dynamic component related to the time of exposure. A sensible model for marine corrosion should incorporate at least some of these parameters in order to better match the environmental conditions that are likely to be encountered.

1.2 Problem Statement

- Corrosion is a major problem in offshore structures, and may cause collapse of the platform. Evaluation of corrosion is very difficult since underwater inspection is involved.
- No studies have been reported on determination of appropriate corrosion allowance for offshore steel structures.

1.3 Objectives

The main aim of this project is to develop an understanding of the condition of the offshore structures and obtain the correct corrosion allowance. The following objectives would be used to achieve the aim:

1. To analyze the condition and degree of deterioration of offshore structures based on inspection reports of various platforms obtained from Petronas CariGali Sdn Bhd (PCSB). The method of Cathodic potential and the Percent wastage of Anode are used for the purpose.
2. To design and fabricate a test set up to determine the nature and rate of corrosion in mm/year at the Boustead Shipyard Lumut.

1.4 Scope of Work

The study focused on the Cathodic Potential and Percentage Wastage of Anodes data obtained from PCSB Underwater Inspection Maintenance Department and the corrosion rate for Type 3 Mild Steel that are imported from Japan and China. There were three major stages during this study:

1. Data gathering and Analysis of Inspection Report
   - All relevant data of Cathodic Potential, Percentage Wastage of Anodes and jacket member's wall thickness were acquired from Petronas Operations.
   - The data on Cathodic Potential, Percentage Wastage of Anodes and jacket member's wall thickness were identified and understood.
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   - An experiment was conducted at the Boustead Shipyard Sdn Bhd to stimulate offshore condition for determining the rate of corrosion.
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3. Laboratory experiments
   - The seawater will be collected together with the corrosion coupons every three months from Boustead Shipyard Sdn Bhd to obtain the salinity and pH. The pH of the seawater can be determined by litmus paper.

Refer Attachment A: How to determine the salinity of the seawater?

CHAPTER 2

LITERATURE REVIEW / THEORY

2.1 General Corrosion

General corrosion is defined as corrosive attack dominated by uniform thinning. The destructive result of chemical reaction between a metal or metal alloy and its environment causes corrosion. The metal atoms are present in chemical compounds. During the chemical reactions, the same amounts of energy needed to extract metals from their minerals that produce corrosion. Corrosion returns the metal to its combined state in chemical compounds that are similar or even identical to the minerals from which the metals were extracted.

Although high-temperature attack in gaseous environments, liquid metals, and molten salts may manifest itself as various forms of corrosion, such as stress-corrosion cracking and de-alloying, high-temperature attack has been incorporated under the term "General Corrosion" because it is often dominated by uniform thinning.

2.2 Forms of Corrosion

Over the years, corrosion scientists and engineers have recognized that corrosion manifests itself in forms that have certain similarities and therefore can be categorised into specific groups. However, many of these forms are not unique but involve mechanisms that have over lapping characteristics that may influence or control initiation or propagation of a specific type of corrosion.

The most familiar and often used categorization of corrosion is: uniform attack, crevice corrosion, pitting, intergranular corrosion, selective leaching, erosion corrosion, stress corrosion, and hydrogen damage. This classification of corrosion is based on visual characteristics of the morphology of attack.

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   - Galvanic corrosion
   - Stray-current corrosion
   - General biological corrosion
   - Molten salt corrosion
   - Corrosion in liquid metals
2. **High-temperature corrosion**
   - Oxidation
   - Sulfidation
   - Carburization
3. **Localized corrosion**
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   - Stress-corrosion cracking
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   - Liquid metal embrittlement
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Uniform Corrosion

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Galvanic Corrosion

Galvanic corrosion and the related inter-granular corrosion can produce highly localised anodic attack and significant loss of section with little or no corrosion being visible. Such corrosion can take place where two dissimilar metals are located next to each other without suitable precautions being taken. Common examples of locations where such corrosion occurs are aluminium roof and wall cladding fixed to carbon steel structures without insulating washers, supporting of pipes and equipment on structures.

Crevice and Pitting Corrosion

Crevice and pitting corrosion are insidious forms of deterioration that produce considerable loss of section at small, localised anode sites which can lead to sudden and unexpected failure. The driving power for pitting corrosion is the lack of oxygen around a small area. This area becomes anodic while the area with excess of oxygen becomes cathodic; leading to very localized galvanic corrosion. The presence of chlorides, example in sea water, significantly aggravates the conditions for formation and growth of the pits through an autocatalytic process.

Stress Corrosion

Stress corrosion and the related corrosion fatigue, require the presence of both stress and a corrosive environment and are characterised by the highly local attack they produce. Such environments are more associated with particular structural locations in nitrate fertilizer factories.

Erosion Corrosion and Fretting

Erosion corrosion and fretting are specialized forms of metallic deterioration that do not require the presence of an electrolyte common in all other forms. The combination of a corrosive fluid and high flow velocity results in erosion corrosion. The same stagnant or slow flowing fluid will cause a low or modest corrosion rate but rapid movement of the corrosion fluid physically erodes and removes the protective corrosion product film exposes the reactive alloy beneath and accelerates corrosion. Despite this, they too can result in local loss of metal section and subsequent sudden failure.

2.3 Mechanism of corrosion

Small physical and/or chemical differences present in metals such as minor impurities or local composition variations or environment for example changes in amount of dissolved oxygen varying with the depth of immersion, non uniform salt concentrations due to pollution, etc will cause corrosion to occur.

There are two types of corrosion which are categorized: dry and aqueous. The former may be described as the metal directly oxidizing, thereby returning to a lower chemical energy level. This type of corrosion is slow and relatively uniform. Temperature and diffusion of oxygen through the oxide determine the rate of corrosion. Thus the thickness and physical stability of the rust layer are significant. The seawater which contains dissolved salts greatly increase the

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There are two types of corrosion which are categorized: dry and aqueous. The former may be described as the metal directly oxidizing, thereby returning to a lower chemical energy level. This type of corrosion is slow and relatively uniform. Temperature and diffusion of oxygen through the oxide determine the rate of corrosion. Thus the thickness and physical stability of the rust layer are significant. The seawater which contains dissolved salts greatly increase the water conductivity and hence its corrosiveness. There must be a complete electrical circuit in both the structure and the aquatic medium. To initiate the corrosion process, the negatively charged ion in the electrolyte flow from where they are produced at the cathode toward the anode. The ions flow from the anode to the cathode unless an opposing voltage is applied with the aim of suppressing this current in the structure itself. The presence of these negative ions near the anode encourages positively charged metallic ions to dissolve into the electrolyte when they combine with any available negative ions to form a corrosion product. If the corrosion product forms a barrier to the ionic movement, the corrosion product can be discontinues. This so called "passive" coating reforms and heal spontaneously provided oxygen is available but rapid corrosion can occur in crevices or under marine growth.

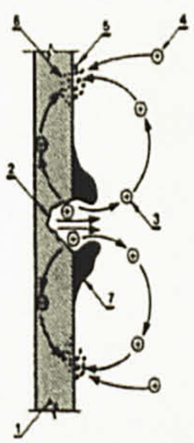

Figure 2. 1: Corrosion of steel immersed in water
1-Steel, 2- Pit, 3-iron ion,4-hydrogen ion,
5- hydrogen film, 6-impurity,7-product of corrosion $Fe(OH)_2$

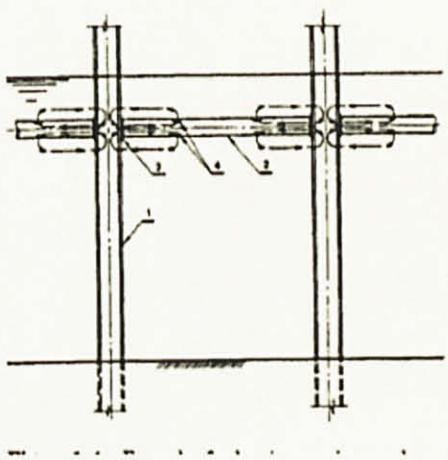

Figure 2. 2: Example of galvanic corrosion
couples(dissimilar- electrode cells.
1-A242 H pile, low alloy steel (cathode),
2-mild steel pipe brace node), 3-weld,
4-pit.Note: Ptting occur current leaves the anode to enter the electrolyte

(Diagram adopted from Tsinker, 1995)

At the anode iron goes into solution

$Fe \text{-}\rightarrow Fe^{2+2} + 2e$ (2.1)

The electron flows to the cathode through the metallic circuit. At the cathode oxygen converts hydrogen atoms into water

$2H^+ + ½ O + 2e \text{--}\rightarrow H_2O$ (2.2)

Or converts water to hydroxyl ions.

$H_2O + ½ O_2 + 2e \text{-}\rightarrow 2OH^-$ (2.3)

Adding the Eqn (a) and (C)

$Fe + H_2O + 1/2O_2 \rightarrow Fe(OH)_2$ (2.4)

Iron is converted to ferrous hydroxide. Other reactions can occur such as conversion of ferrous hydroxide ($Fe(OH)_3$) by further reaction with oxygen.

2.4 Environment Factor

Environments are difficult to define and their broad and uncertain variability reduces the predictability to which the materials are exposed.

<u>Presence of mibrobes</u>

Microbes are present everywhere in soils, freshwater, seawater and air. The microbes of sulfate reducing bacteria is one of the wide spread types of corrosion fracture of materials. A corrosion problem does not indicate merely by detection of microorganisms in an environment. The number of microorganisms of the specifically corrosive types will determine the corrosion problem. (Pogrebova, et. al, 2001)

Microbiologically influenced corrosion (MIC) is responsible for the degradation of a wide range of materials. Figure 2.3 shows a useful representation of materials degradation by microbes in the form of pipe cross section. (Hill, 1970) Microorganisms can attack most metals and their alloys, (e.g. stainless steels, aluminium and copper alloys, polymers, ceramic materials, and concrete.

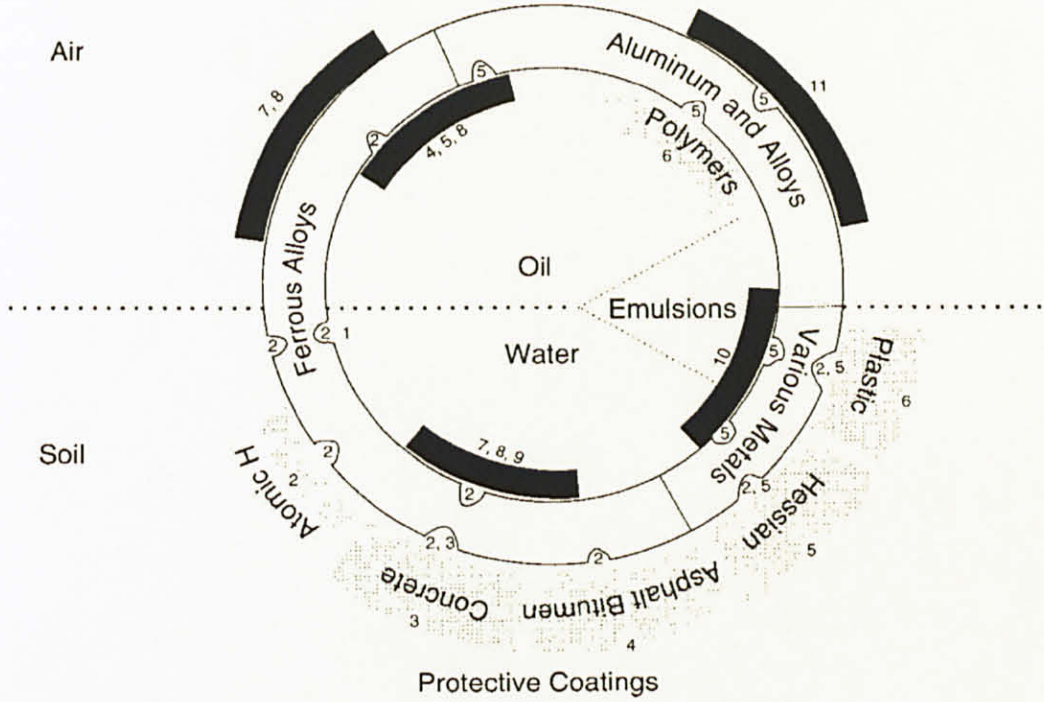

Figure 2.3: Schematic illustration of the principle methods of microbial degradation of metallic alloys and protective coatings (Source: Hill, 1970)

1. Tubercle leading to differential aeration corrosion cell and providing environment for "2".
2. Anaerobic sulfate reducing bacteria (SRB).
3. Sulfur oxidizing bacteria, providing sulfates and sulfuric acid.
4. Hydrocarbon utilizers, breaking down aliphatic and bitument coatings and allowing access of "2" to underlying metallic structure.

5. Various microbes producing organic acids as end products of growth, attacking mainly non ferrous metals alloys and coatings.
6. Bacteria and modls breaking down polymers.
7. Algae forming slimes on above ground damp surfaces.
8. Slime forming molds and bacteria (which may produce organic acids or utilize hydrocarbons) providing differential aeration cells and growth conditions for "2".
9. Mud on river bottoms and so on providing matrix for heavy growth of microbes (including anaerobic condition for "2")
10. Sludge (inorganix debris, scale, corrosion products, etc.) providing matrix for heavy growth and differential aeration cells, and organic debris providing nutrients for growth.
11. Debris (mainly organic) on metal above ground, providing growth conditions for organic acid-producing microbes.

Flow effect

Exposure of the metallic surface to high flow rates can accelerate the corrosion damage due to the destruction of a protective film. For example carbon steel pipe carrying water is usually protected by a film of rust that slows down the rate of mass transfer of dissolved oxygen to the pipe wall. The corrosion rates are typically < 1mm per year. The removal of the film by flowing sand slurry has been shown to increase the corrosion rate 10-fold to ~10mm per year.

Figure 2.4 illustrates the various states of anoxide surface film behaviour as liquid velocity or surface shear stresses are increased (Chexial et.al, 1998). The summary of change in the corrosion and erosion mechanisms associated with flow accelerated corrosion (FAC) is in Figure 2.5 and Figure 2.6. The corrosion rate is low and decreases parabolically with time due to the formation and growth of a corrosion protective film at the surface (curve a in Figure 2.5) in stagnant water. Corrosion steams from a flow conditions coexist at low flow velocities for which laminar and turbulent flow conditions coexist. (Parts A and B of Fig. 2.4). The flowing water will dissolve the protective film that forms on the surface by corrosion. The phenomenon is generally accepted as a steady state process. Linear corrosion kinetics (curve b in Figure 2.5) is exhibited and this part is the dissolved layer at the oxide. A new layer of the same thickness will replaced the water interface.

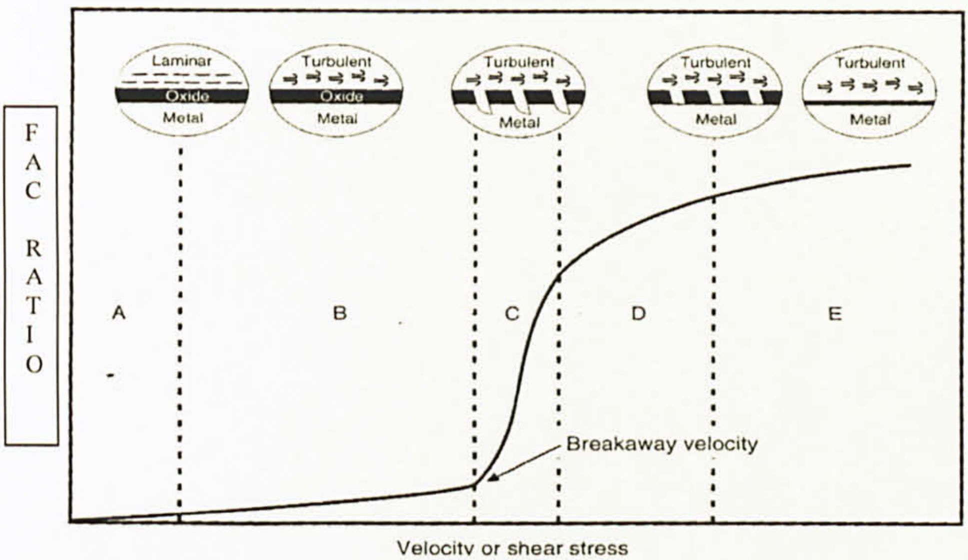

Figure 2.4: Changes in the corrosion and erosion mechanisms as a function of liquid velocity.
(Source: Chexial B, et.al, 1998)

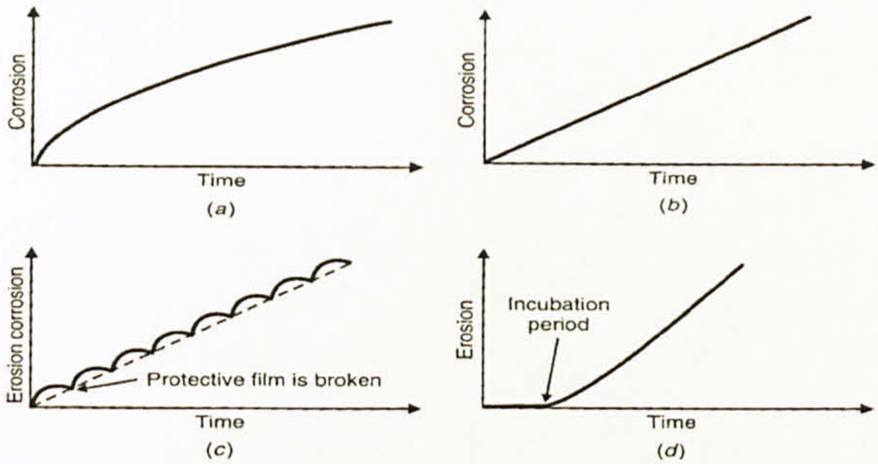

Figure 2.5: Various time dependent corrosion-erosion behaviours and processes: (a) corrosion follows a parabolic time law, (b) Flow Accelerated Corrosion follows a linear time law, (c) erosion and corrosion follows a quailinear time law with repeated breaks in the protective surface film and (d) erosion linear time dependency after an initial incubation period.
(Source: Chexial, et.al 1998)

Dissolution increases

Mechanical damage increases

In static aqueous solutions, the oxide fill grows according to the oxide growth kinetics. The bare metal dissolution rate and passivation rate is a function of the corrosion rate. The corrosion kinetics follows a parabolic time law.
Flow thins film to an equilibrium thickness that is a function of both the mass transfer rate and oxide growth kinetics. The FAC rate is a function of the mass transfer and the concentration driving force. The flow accelerated corrosion (FAC) kinetics follows a linear time law.
The surface shear stress or dissolution or particle impacts locally remove the film but it can be repassivated. The damage rate is a function of the bare metal dissolution rate, passivation rate and the frequency of oxide removal. The damage kinetics follows a quailinear time law.
The dissolution or surface shear stress locally removed the film and the damage rate is equivalent to the bare metal dissolution rate. The kinetics follows a quasilinear time law.
The overall loss rate is contributed by the removal of film and the underlying metal surface is "mechanically damaged". The bare metal dissolution rate plus a possible synergistic effect due to the mechanical damage is equal to the damage rate. The damage rate follows a nonlinear time law.
The oxide film is removed and mechanical damage to the underlying metal is the dominant damage mechanism. The erosion kinetics follows a nonlinear time law.

Mechanical damage dominant

Figure 2.6: Summary of damage mechanisms experienced with FAC.
(Source: Chexial, et.al, 1998)

Temperature Factor

The service temperature close to or above their stability limit will greatly affect the metal. Temperature affects reaction rates, surface temperature, heat flux and associated surface concentrations and temperature gradient chemical transfer in aqueous environments. An increase in temperature is accompanied by an increase in reaction rate in most chemical reactions. The reaction rate doubles for each 10° Celsius (°C) rise in temperature. This is suggested by a rough rule of thumb. It is vital to take into consideration the influence of temperature when analyzing why materials fail and in designing to prevent corrosion although there are numerous exceptions to the rule (Roberge, 2004).

Salinity

There are two main ways of determining the salt content of water which includes Total Dissolved Salts (or Solids) and Electrical Conductivity. Total Dissolved Salts (TDS) is measured by evaporating a known volume of water to dryness, then weighing the solid residue remaining. Electrical conductivity (EC) is measured by passing an electric current between two metal plates (electrodes) in the water sample and measuring how readily current flows (ie conducted) between the plates. The more dissolved salt in the water, the stronger the current flow and the higher the EC. Measurements of EC can be used to give an estimate of TDS (Anderson and Cummings, 1999).

The differences in salinity of seawater are very little between the major oceans with an average salinity level typically in the range 30-35parts per thousand. Water salinity has relatively little direct effect on corrosion rate, at least in the short term, a result first demonstrated in classical laboratory experiments by Heyn and Bauer (1910) and confirmed by Mercer and Lumbard, 1995 in very carefully conducted experiments. According to DNV-RP-B401, the major seawater parameter affecting CP in situ includes salinity.

pH Effects

The range 4-10, pH has little effect on the early rate of corrosion including in seawater. It may have a modest effect on the rate of metabolism of the bacterial and marine growth (fouling) that commences, typically immediately on immersion of steel in seawater. The rate of metabolism is the principal corrosion action of bacteria. Therefore the rate of corrosion tends to reduce with higher pH values at the corroding surface.

Calcium and magnesium carbonates present in seawater and in hard fresh waters are known to form deposits within the corrosion rust layers. The reduction in rate of supply oxygen to the corroding surface will reduce the corrosion rate. The ability of the carbonates to deposit increases with increasing pH of the water. The pH in seawater normally varies only very little (usually between 8.0 and 8.3 due to the buffering capacity of seawater). Therefore the calcium carbonate balance of the water as controlled by the pH of the water plays an important role in determining the rate of corrosion for longer exposure (Robert, et.al, 2007).

The pH in seawater and carbonate content affect the formation of calcareous layer associated with cathodic protection and thus the current needed to achieve and maintain cathodic protection of bare metal surfaces (DNV-RP-B401, 2005).

It is not feasible to give an exact relation between the seawater environmental parameters such as pH and salinity and cathodic current demands to achieve and to maintain cathodic protection. This is due the variation of geographical location, depth and season.

Steel composition

Small changes (say <0.5%) in alloys used in steel composition should have zero or negligible effect on the degree of corrosion that occurs while oxygen diffusion controls the corrosion process according to corrosion science theory (Robert, et.al, 2007).

More specialize steel with larger alloy compositions will have a lower initial rate of corrosion particularly for alloying elements such as chromium, molybdenum and aluminium and to a lesser extent for nickel, silicon, titanium and vanadium. Carbon content has essentially no effect on initial rate of corrosion (Melchers, 2003).

2.5 Corrosion at Seawater

Seawater is one of the most corrosive and most abundant naturally occurring electrolyte. The structural metals and alloys are attacked by seawater and its surrounding environments. There are five zones at the seawater environment which include the subsoil, continuously submerged, tidal, splash zone above high tidal and atmospheric zone.

Each zone gives different results. Oxygen, biological activities, pollution, temperature, salinity and velocity are the major factors which affected the corrosion behaviour of materials in the submerged zone.

The offshore corrosion rate as steel thickness loss per year is given in Table 2.1 Localized higher rates of corrosion can occur due to several mechanisms; these conditions, applicable corrosion rates and preventive measures are discussed below in the section concentrated corrosion.

Table 2.1: Offshore corrosion rate measured as steel thickness loss per year.

Area	Corrosion rate (steel loss per year)
Atmospheric zone(C5-M)	80-200μm (3-8mils)
Splash zone	200-500μm (8-20mils)
Immersion (Im2)	100-200 μm (4-8mils)

(Source: Rasmussen, 2006)

At atmospheric zone, the corrosion rate of unprotected steel is typically in range of 80-200 μm (3-8mils) per year-for comparison most steel structures placed inland are situated in zones classified C3 where the corrosion rate is only 25-50 μm(1-2mils) per year. The extended periods of wetness and high concentration of chlorides that accelerate corrosion causes high corrosion rates. The UV-light from the sun is also another factor that causes degradation. At splash zone highest stresses-corrosion rates of 200-500 μm (8-20mils) per year have been measured. Erosion of water and possible debris may also contributes to this corrosion. At immersion area which is at the lowest tide, fouling could leads to corrosion (Rasmussen,1998 ISO 12944-2:1998).

2.6 Cathodic Protection

Corrosion protection of the critical components of offshore platforms, such as nodes, is accomplished by cathodic protection of the entire underwater jacket area for all the Petronas platforms. Cathodic protection prevents corrosion by converting all of the anodic (active) sites on the metal surface to cathodic (passive) sites by supplying electrical current (or free electrons) from an alternate source.

Usually this takes the form of galvanic anodes, which are more active than steel. This practice is also referred to as a sacrificial system, since the galvanic anodes sacrifice themselves to protect the structural steel or pipeline from corrosion.

In the case of aluminium anodes, the reaction at the aluminium surface is: (four aluminium ions plus twelve free electrons)

$4Al \Rightarrow 4AL^{+++} + 12\ e^{-}$

and at the steel surface, (oxygen gas converted to oxygen ions which combine with water to form hydroxyl ions)

$3O_2 + 12e^{-} + 6H_20 \Rightarrow 12OH^{-}$

As long as the current (free electrons) is arriving at the cathode (steel) faster than oxygen is arriving, no corrosion will occur.

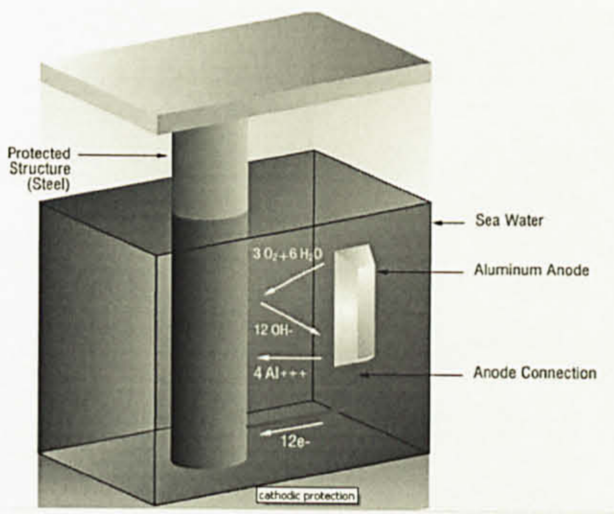

Figure 2.7: Sacrificial anode system in seawater (Richard and Jim, 2008)

2.7 Basic Considerations When Designing Sacrificial Anode Systems

The Ohm's law controlled the electrical current which an anode discharges; that is $I = E/R$

I = Current flow in amps

E = Difference in potential between the anode and cathode in volts

R = Total circuit resistance in ohms

Initially current will be high because the difference in potential between the anode and cathode are high, but as the potential difference decreases due to the effect of the current flow onto the cathode, current gradually decreases due to the polarization of the cathode. The circuit resistance includes both the water path and the metal path, including any cable in the circuit. The dominant value here is the resistance of the anode to the seawater (Richard and Jim, 2008).

In general, short fat anodes have higher resistance than long thin anodes. They will discharge more current, but will not last as long (Richard and Jim, 2008).

Therefore the right shape and surface area to discharge enough current to protect the structure and enough weight to last the desired lifetime when discharging the current is vital. As a general rule of thumb:

1) Length of the anode determines how much current the anode can produce, and consequently how many square feet of steel can be protected.

2) Cross Section (Weight) determines how long the anode can sustain this level of protection.

The underwater inspection and reporting requirements state that the cathodic potential measurements(CPS) should be taken at specified cathodic potential survey positions (CPSP) (usually nodes and the mid points of structural braces by Remote Operated Vehicle (ROV).

In cases of anomalies C.P measurement are to be taken with the handheld bathycorrometer. The Bathycorrometer allows a diver/inspection engineer to select a given location, on an immersed structure, at which the structure to sea water potential is to be measured. The electrochemical potential of the structure under investigation at this location can be determined to a high degree of accuracy (+/-5mV). (Buckley, 2007)

The minimum value for cathodic protection to work can be determined by measuring the potential of the steel against a standard reference electrode, usually silver silver/chloride (Ag/AgCl sw.), but sometimes zinc.

Current flow onto any metal shifts its normal potential in the negative direction. History has shown that if steel receives enough current to shift the potential to (-) 800 mV vs. silver / silver chloride (Ag / AgCl), the corrosion is essentially stopped. (Buckley 2007)

Due to the nature of the films which form, the minimum (-800 mV) potential is rarely the optimum potential, and designers try to achieve a potential between (-) 950 mV and (-) 1000 mV vs. Ag/AgCl sw. (Richard and Jim, 2008)

In cases of anomalies (measurements more positive than -800mV or more negative than -1200mV) further contact C.P measurements (CPS) are required (preferably using a diver handheld bathycorrometer review) at additional locations to determine the extent of the C.P. anomaly and the optimal maintenance solution.(PCSB Underwater Inspection Maintenance, 1995).

The measured potential will enable an assessment of the level of cathodic protection on the structure under investigation to be obtained. If the potential is less than (-) 800 mV vs an Ag/AgCl reference electrode in aerobic conditions, then insufficient levels of cathodic protection are being achieved. If the potential is in excess of (-)1100 mV vs Ag/AgCl electrode, then excess levels of cathodic protection are being applied and there is a danger of cathodic disbondment, detachment of the structure coating. Indeed, in the case of high tensile steels, a high negative potential may cause hydrogen embrittlement. (Buckley 2007)

Hydrogen embrittlement occurs in a number of forms but the common features are an applied tensile stress and hydrogen dissolved in the metal.

The embrittlement of steel by atomic hydrogen involves the ingress of hydrogen into the component, an event that can seriously reduce the ductility and load-bearing capacity, causes cracking and catastrophic brittle failures at stresses below the yield stress of susceptible materials.

However, in the design procedure advised in DNV-RP-B401, the protective potential is not a variable. The protection potential for the main part of the design life will be in the range (-) 900 mV to (-) 1050 mV for a correctly designed galvanice anode cathodic protection system. The potential increases rapidly towards (-) 800 mV and eventually to even less negative values referred to as 'underprotection' towards the end of the service life. The term 'over protection' is only applicable to protection potentials more negative than (-) 1150 mV. This is not application for cathodic protection by galvanice anodes based on Al or Zn (DNV-RP-B401, 2005).

Cathodic protection system will not work for the splash zone. This is because the surface are intermittently wetted. The influence of winds, tide and seas will ensure an ample supply of ozygen and also removal of corrosion products. Therefore the general corrosion rate in this zone will be higher than on the submerged part of the structures.

2.8 Evaluation of the Condition and Degree of Deterioration of Offshore Structures

According to the PCSB Underwater Inspection Maintenance Manual, the condition and degree of deterioration of offshore structures is evaluated by the major platform inspection. The followings are the standard scope of work.

1) Above water jacket Configuration Photographs and topside condition.

   Take the above water configuration photographs of all jacket faces and record the date and time of each photograph.
   If access permits, visually inspect the condition of the above water structural members at the splash zone area. Any defects found are illustrated in the photograph.

2) Splash Zone Corrosion.

   Inspection on all the surface breaking structural members (legs and vertical diagonal member (VDMs) as close to MSL as sea condition limits is carried out in the detailed splash zone coating inspection.
   One wall thickness measurement and one CP measurement on each splash zone piercing member is taken.

3) Contact Cathodic Potential Measuring

At specified Cathodic Potential Survey Position, contact C.P measurements are required. Remote CP measurements are not acceptable.
In cases of anomalies (measurements more positive than -800mV or more negative than -1200mV) further contact C.P measurements (CPS) are required (preferably using a diver handheld bathycorrometer) at additional locations to determine the extent of the C.P. anomaly and the optimal maintenance solution.

The major types of anodes for offshore structures consist of slender stand off, elogated, flush mounted and bracelet. The selection of anode types are based on sea current drag and interference with subsea interventions. Besides that the net anode mass to be installed and available space for location of anodes shall be taken into account in selecting anode type. The size and geometrical configuration of the protection object, in addition to forces exerted on anodes during installation and operation are the criteria during the selection of anode type.

The standard scopes of Work in the PCSB Underwater Inspection Maintenance Manual state that the anodes depletion status and the integrity of mountings should be determined. Swain ammeter current output measurements must be taken on each anode stub. The anode is hand cleaned sufficiently to provide an accurate estimate of percentage depletion on completion of the current output. On CARIGALI instruction, all anodes which have become 90% depleted should be replaced.

Table 2.2: Splash zone corrosion protection provision for steel structures by different authorities

Det Norske Veritas	The Norwegian Petroleum Directorate	Norsok
1977: Special corrosion protection system (not defined) and minimum 12 mm corrosion allowance.	Prior to 1992: Minimum 10mm corrosion allowance.	1994: Corrosion allowance and coating. For thin film coating:corrosion allowance minimum 5mm. for design lives >17.5years, corr. Allowance =(design life-5 years) x 0.4mm/year.
	1992: Coating and corrosion allowance. For thin film coating (thickness <1mm); Corrosion allowance = (design life-5 years) x 0.4mm/year; minimum 5mm. Reduction if: 1. Structure is inspected in dry dock or sheltered water at least every 5 years, and/or 2. Coating with	

	thickness more than 1mm (rubber) or sheathing is used. No quantitative reduction guides given. 1999: same as Norsok	

Source: DNV, 2000; NACE Standard Recommended Practice RP0176-94 and Norsok Standard M-001

2.9 Types of Steels in Offshore Structures

The steel products used in offshore structure shall comply with the general requirement of the standard and with the specific requirement of the grade concerned. The design and engineering practise for weldable structural steels for fixed offshore structure stated in Petronas Technical Standards classified the materials into 4 groups.

Type 1 Steel: Primary Structural Steel – High strength

Primary structural steel (high strength) is steel with yield strength of 50 ksi and over and used in members essential to the overall integrity of the structure and for other structural members of importance to the operational safety of the structure.

Type 2 Steel: Primary Structural Steel - High Strength with Through Thickness Properties.

Primary structural steel- (high strength) with through thickness properties, is steel with a yield strength of 50 ksi and over and used in members essential to the overall integrity of the structure, where stress concentrations are high and where the stresses in the through thickness direction may lead to lamellar tearing.

Type 3 Steel: Primary Structural Steel- Mild Steel

Primary structural steel- (mild steel) is steel with yield strength between 36 ksi and 50 ksi and used in members essential to the overall integrity of the structure and for other structural members of importance to the operational safety of the structure.

Type 4 Steel: Primary Structural Steel- Mild Steel with Through Thickness Properties.

Primary structural steel- (mild steel) with through thickness properties is steel with a yield strength between 36 ksi and 50 ksi and used in members essential to the overall integrity of the structure, where stress concentrations are high and where the stresses in the through thickness direction may lead to lamellar tearing.

2.10 Corrosion behaviour of metals and alloy

There are differences on the corrosion behaviour of metals and alloys from one zone to another. The carbon and low alloy steels do not have satisfactory performance in splash zone. Anderson and Ross (1976) had found that the austenitic grades performed much better than martensitic and ferritic grades. Austenitic is metallic non-magnetic solid solution of iron and an alloying element. The martensitic is a very hard form of steel crystalline structure. Carbon steel in splash zone is less resistant than Ni, Cu and P alloyed steels. Besides that, it was found that Mn, P and Al had measurable influence on corrosion rates of low carbon steels under tidal exposure. The rate of attack in splash zone was much higher than the atmosphere and deep submerged zone after 5 years exposure test (Fozan and Malik, 2005).

Rectangular test specimens of different alloys with 50x20x2 mm dimension were utilized in the experimental work. The specimens were exposed to seawater under different levels. The test specimens were abraded on 400 grit SiC paper to remove the corrosion by product. Weight loss coupon method technique had been used to determine the corrosion rates (Fozan and Malik, 2005).

The corrosion rates of the specimens at semi submerged location for all the tests are higher than the other locations. The most affected area in test specimens was found at water line zone. This attack could be due to the formation of differential aeration cell. Due to low oxygen solubility in water the oxygen concentration will be higher above the water surface.

The carbon steel 304SS and 316L SS have been markedly affected by water line corrosion. With increase of nickel content in copper base alloys the resistance to water line corrosion increase. Titanium addition to Incoloy 825 has beneficial effect at semi submerged location in minimizing the pitting depth. Incoloy 825 is a nickel-iron-chromium alloy with additions of molybdenum, copper and titanium to provide exceptional resistance to various corrosive environments (Fozan and Malik, 2005).

The composition in the test specimen will also affect the rate of corrosion. This will be taken into account in this project. The test specimens used will be chosen according to the requirement in Petronas Technical Standard.

Yasunobu, Kenichi, Kaoru and Masanori (2008) had completed trial tests for an actual environment to evaluate the applicable range and practical performance of the method combining the electrode deposition and cathodic protection method. Circulation test cell was conducted in the Port which is located at off the shore of Kurihama (Kanagawa Prefecture) and Research Institute simulating tidal zone. The installation environment consists of highest water level and lowest water level.

Table 2.3: Experimental Conditions (Trial tests under actual environment)

(Source: Yasunobu, Kenichi, Kaoru and Masanori, 2008)

Items		Unit	Specifications	
Electrolyte	Sample solution	—	Natural seawater	
	Sampling location	—	Off the shore of Kurihama (Kanagawa Prefecture)	
	pH	—	7.94 (at 26.5°C)	
	Salinity	%	2.8	
Cathode	Material	—	SS400 (JIS G 3101)	
	Size	mm	70 × 150 × 3.2	
	Effective surface area	cm^2	220	
Anode	Material	—	Lead, silver alloy	
	Size	mm	ϕ25 × 250	
Cathode current density		A/m^2	2.0	
Installation environment of test pieces		—	A	B, C, DH, DL
Electricity		$A{\cdot}d/m^2$	7.0	14.0

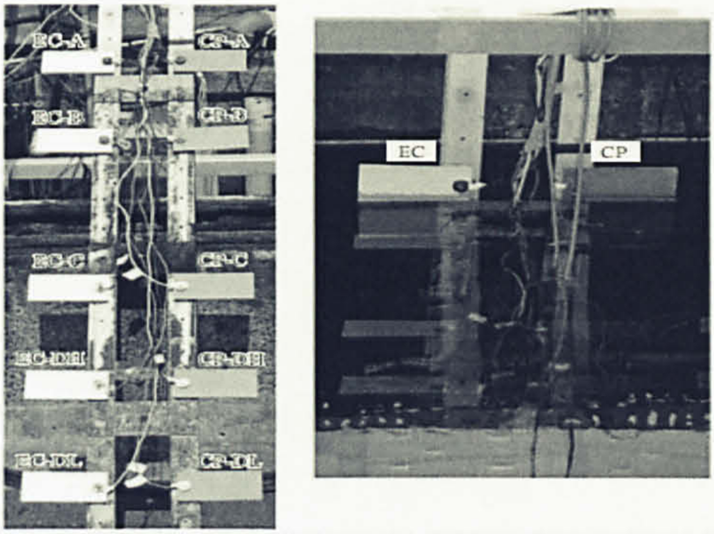

Figure 2.8: Installation of each test piece (Source: Yasunobu, Kenichi, Kaoru and Masanori, 2008)

Studies on corrosion allowance in Malaysia for offshore steel structures have not been systematically undertaken nor have they been reported in literature. The factors affecting the rate of corrosion were widely studied by researcher. All these factors will be taken into account in this project to achieve the optimum results.

CHAPTER 3

METHODOLOGY AND PROJECT WORK

For this project, the PCSB Underwater Inspection Maintenance data is collected and analysed. An experiment is conducted which involves fabricating of samples (corrosion coupons) of different types of tubular members and immersing the same in different seawater zones at the BOUSTEAD shipyard at Lumut. Each corrosion coupon is pre-weighed to an accuracy of two decimal places. The corrosion coupon will be left in seawater at Lumut for duration of three years. The corrosion coupon are then removed every 3 months and sent to University Teknologi Petronas laboratory for analysis. The set up of the experiment is shown in Figure 3.1. The coupons will be typically photographed as received, cleaned of any attached debris and deposits, visually inspected, dried and re-weighed, and then photographed again to show surface conditions. The corrosion rate of the coupon in mils per year can then be estimated based upon the weight of material lost over its time in service.

3.1 Analysis of Inspection Report

1. Obtain the data on the rate of Cathodic Potential and wastage percentage on Anodes that is available on selected members & jacket legs at different zones from Petronas Operating Units.
2. Tabulate the data.
3. Analyze and summarize the data obtained.

3.2 Experimental Phase

1. Fabrication of two sets of corrosion coupons of Type 3 Steel which consist of mild Steel from China fabricator and Japan fabricator.
2. Each of the corrosion coupons are stamped with number for identification purposes.
3. At atmospheric and fully immersed zone, 3" strip coupon will be installed. The dimension of the corrosion coupons will be 73x22x3.8mm with one mounting hole.
4. At the tidal zone, 6" strip coupons will be installed since the tide level is likely to fluctuate more than 3 inches. The dimensions of the 6" strip coupon are 152mm x 22mm x 3.8mm.
5. Four coupons will be placed on atmospheric, semi-submerged and totally submerged zones.
6. The samples will be periodically inspected.
7. The sea water sample will be taken every 3 months to test for the salinity and pH.
8. The corrosion coupons are cleaned to remove the corrosion by-product either by scraping with sand paper or by pickling.
9. Weight loss of coupon method will be used to determine the corrosion rates.
10. The results obtain are compared with the recommendations of the code.
11. Recommendations for corrosion allowance will be made based on these results.

Refer Attachment B: Process on the fabrication and installation of corrosion coupons and frames displayed in pictures.

Below are the selected locations to conduct the experiment.

1. **Boustead Naval Shipyard Sdn. Bhd. Jetty.**

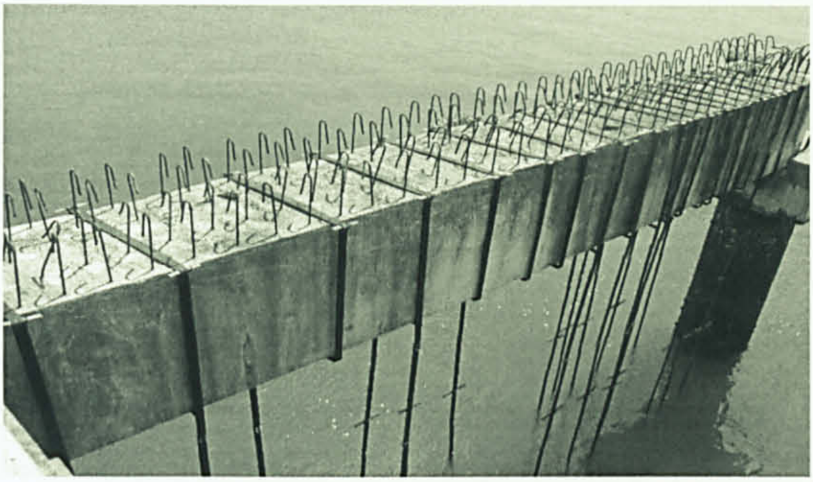

Figure 3.1: Boustead Naval Shipyard Sdn. Bhd. Beam with corrosion sample.

The Boustead Shipyard Sdn Bhd was selected to set up the experiment because it is a safe and secure location. This ensures that the set up of the experiment would not be tampered. Besides that this area meets the requirements to conduct this experiment which are to simulate the offshore structural condition eg. fully immersed zone, splash zone and atmospheric zone.

CHAPTER 4

RESULTS AND DISCUSSION

The data obtained from inspection reports are final analysis and discussion. This report details the inspections result relating to splash zone inspection and cathodic potential survey. There were 5 platforms chosen for this data analysis which includes Platform C, D, E, F and G. The summary of the platform Inspections with respect to the baseline inspection and year were shown on Table 4.1. The discussion for the inspection reports will be in data gathering and Analysis of Inspection Reports. This section provides a synopsis of the findings while the results for each part of the work scope are described in the relevant sections of the report. The details of the experimental work are discussed in the last sections.

Table 4.1: Summary of Platforms Inspection

			Inspection					
Platform	Installation year	Baseline	1986	1989	1991	1994	2002	2003
Platform -C	1976	Nil		√		√	√	
Platform-D	1976	Nil		√		√		√
Platform -E	1976	Nil	√		√		√	
Platform -F	1980	Nil				√		√
Platform -G	1980	Nil			√		√	

4.1 Analysis of Inspection Reports.

4.1.1 Cathodic Potential Survey Analysis

This report details the inspections result relating to splash zone inspection and cathodic potential survey. This section provides a synopsis of the findings while the results for each part of the work scope are described in the relevant sections of the report. Supplementary information may be found in the appendices. Photographs enclosed in the section of the report where appropriate are selected based on clarity and sharpness of the pictures. The inspections of the structure were executed by Air Divers and Remote Operated Vehicles (ROV).

Divers carried out the splashzone coating inspection on all the surface piercing members. The analysis showed a gap in the inspection history of Platform Jacket after the installation process of the platform. After platform was installed in 1976, a baseline inspection should have been carried out in 1977. The future inspection results can be compared with this baseline inspection data. However, the baseline data is not available. The baseline inspection was carried out but the data was not found by PCSB.

According to the data obtained, the first inspection for Platform Jacket-C (Platform-C) was done on 1989. Table 4.1 shows the cathodic potential measurement details of a few selected members for the year 1989, 1994 and 2002. The platform is now 34 years old. The data on jacket member's wall thickness is scattered and missing. Only inspection data on wall thickness for 1989 is available therefore a comparison between these inspections cannot be done. For this analysis, the cathodic potential measurement and percentage wastage on anodes were taken. The cathodic potential measurement ranged from (-) 931 mV to (-) 949 mV on 1989. In cases of anomalies measurements more positive than -800mV or more negative than -1200mV) further contact cathodic protection measurement (CPS) are required at additional locations to determine the extent of the cathodic protection anomaly and the optimal maintenance solution (PCSB Underwater Inspection Maintenance Manual). However the values obtained from this general inspection were in this range therefore indicating adequate protection.

Another general Inspection was done on 1994 and the cathodic potential measurement ranged from (-) 903mV to (-) 954mV. The values were ranged between (-) 800mV to (-) 1200mV. Therefore the protection was adequate.
In year 2002, another inspection was done on Platform C Jacket. Cathodic potential measurement ranged from (-) 946 mV to (-) 955 mV was taken. No instances anomalous (low) cathodic protection potential readings were reported in the cathodic protection potential survey.

Table 4.2: General Inspection on Platform Jacket-C on Cathodic Potential (Platform-C)

Structure Identification	Structure function	Installed
PLATFORM-C	Cluster Drilling	1/4/1976
Date of Cathodic Potential Survey	ID	CP value (-mV)
11Aug-28Oct 1989	1	944
	2	931
	3	931
	4	947
	5	949
	6	941
	7	937
	8	948
22-28 Aug 1994	VDM-N2-N19	951
	VEM-N2-N15	954
	VDM-N1-N17	918
	VEM-N4-N12	903

	VDM-N4-N21	934
	VDM-N3-N20	952
	VEM-N3-N13	948
22-27 Mar 2002	VEM N2-N15	954
	VEM N3-N13	952
	VDM N3 N20	955
	VEM N4-N14	946
	VDM N4-N21	949
	VEM N1-N16	947
	VDM N1-N22	951
	VDM N2-N19	955

Table 4.2 shows the cathodic potential values for a few selected members which pierce MSL for the year 1989, 1994 and 2002. The numbering scheme was 1, 2, 3 and etc in 1989 but was changed to VDM-N2-N9 in 1994 and 2002. In year 1989, general inspection in PLATFORM-D was carried out. Cathodic protection ranged from (-) 940 mV to (-) 951mV indicating adequate protection. The jacket structures general inspection was done on year 1994 and year 2003. The cathodic protection ranged from (-) 929mV to (-) 932mV for year 1994 and (-) 892mV to (-) 914mV for year 2003. The values were ranged between (-) 800mV to (-) 1200mV. Therefore the protection was adequate.

Table 4.3: General Inspection on Platform Jacket-D on Cathodic Potential (PLATFORM-D)

Structure Identification	Structure function	Installed
PLATFORM-D	Cluster Drilling	September 1976
Date of Cathodic Potential Survey	ID	CP value (-mV)
19 -25 Aug 1989	1	949
	2	951
	3	947
	4	947
	5	942
	6	942
	7	940
	8	941
20 - 22Aug 1994	VEM-N1-N15	932
	VDM-N1-N16	932
	VEM-N4-N11	929
	VEM-N4-N10	932
24th Sept 2003	VDM N1-N16	908
	VDM N2-N13	914
	VDM N3-N17	903
	VDM N4-N10	900
	VEM N1-N15	903
	VEM N2-N14	907
	VEM N3-N12	901
	VEM N4-N11	892

In year 1986, general inspection was carried out on PLATFORM-E. The cathodic potential value measurements are shown in Table 4.3. The cathodic potential survey has shown that the measurements ranged from (-) 839mV to (-) 878mV indicating adequate protection. The following general inspection was done on 1991 and 2002. The cathodic potential ranged from (-) 893mV to (-) 923mV and (-) 904mV to (-) 925mV respectively. The values were ranged between (-) 800mV to (-) 1200mV. Therefore the protection was adequate.

Table 4.4: General Inspection on Platform Jacket-E on Cathodic Potential (PLATFORM-E)

Structure Identification	Structure function	Installed
PLATFORM-E	Cluster Drilling	September 1976
Date of Cathodic Potential Survey	ID	CP value (-mV)
05-22 Oct 1986	VEM a2-b2	860
	VDM	850
	VEM b1-a1	839
	VDM	855
	VEM a1-a2	850
	VDM	854
	VEM b2-b1	856
	VDM	878
	VEM b2-b1	856
	VDM	878
10 -16 Mar 1991	VDM-N3-N11	893
1st July 1991	VDM-N4-N18	917
	VDM-N2-N14	923
	VDM-N1-N17	923
31 Mar -4 Apr 2002	VEM N1-N19	925
	VEM N2-N20	913
	VEM N3-N22	909
	VEM N4-N21	910
	VDM N1-N17	921
	VDM N2-N14	921
	VDM N3-N11	904
	VDM N4-N18	913

Splashzone inspections were done on PLATFORM-F which was in 1994 and 2003. Table 4.4 shows the general inspection details of a few members for the year 1994 and 2003. There is no data on the earlier years. This might due to misplacement of data or error during handling process of the data when Shell handed over to Petronas in the earlier years. Eight members of the jacket pass through the air/water interface, comprised as four vertical diagonal members (VDM's) and four jacket legs (VEM's). Inspection of these members through the splashzone is reported to have confirned the cathodic potential plus the absence of corrosion. In year 1994, the cathodic potential values ranged from (-) 917mV to (-) 928mV. In year 2003, the cathodic potential value ranged from (-) 891mV to (-) 904mV. No instances of anamalous (low) cathodic protection potential values were reported in respect of splashzone members for both the year.

Table 4.5: General Inspection on Platform Jacket-F on Cathodic Potential (PLATFORM-F)

Structure Identification	Structure function	Installed
PLATFORM-F	Cluster Drilling	August 1980
Date of Cathodic Potential Survey	ID	CP value (-mV)
16 - 20 Aug 1994	VEM-N3-N68	917
24 - 28 Aug 1994	VDM-N3-N61	918
5 - 6 Sep 1994	VEM-N3-N67	928
	VDM-N2-N59	923
	VEM-N1-N66	928
	VEM-N4-N69	917
	VDM-N1-N60	920
	VDM-N4-N58	919
19 - 23 Sep 2003 and 8 Oct 2003	VEM N1-N66	899
	VEM N2-N67	899
	VEM N3-N117	895
	VEM N4-N69	892
	VDM N1-N69	899
	VDM N2-N59	904
	VDM N3-N61	898
	VDM N4-N58	891

In year 1991 and 2002, splashzone inspections were done on PLATFORM-G. The details are shown in Table 4.5. There is no data on the earlier years. This might due to misplace of data or error during handling process of the data when Shell handed over to Petronas in the earlier years. In year 1994, ten members of the jacket were inspected. The anodes were found missing at no A12 on VDM-N17-N22 at elevation (-)8 meters the and no A3 on VDM-N11-N21 at elevation (-)5 meters. The reason of missing anodes was not stated in the report. The cathodic potential value ranged from (-) 852mV to (-) 903mV in year 1991. In year 2002, the cathodic potential value ranged from (-) 850mV to 872mV. Both were reported to display adequate levels of cathodic protection.

Table 4.6: General Inspection on Platform Jacket-G on Cathodic Potential(PLATFORM-G)

Structure Identification	Structure function	Installed
PLATFORM-G	Cluster Drilling	September 1980
Date of Cathodic Potential Survey	ID	CP value (-mV)
9-Mar-91	VEM-N4-12	852
	VDM-N4-N11	883
	VEM-N3-N13	895
	VDM-N3-N18	896
	VEM-N2-N15	898
	VDM-N2-N14	916
	VEM-N1-N16	887
	VDM-N1-N17	903
4 - 6 Apr 2002	VEM N1-N19	870
	VEM N2-N20	872
	VEM N3-N21	858
	VEM N4-N22	852
	VDM N1-N17	868
	VDM N2-N14	870
	VDM N3-N18	863
	VDM N4-N11	850

4.1.2 Anode Inspection Analysis

Two methods were used to perform the anode depletion inspection. The general anode depletion inspection was done using the Remote Operated Vehicle (ROV). As for the detailed inspection, it was done on selected anodes by the diver. Theoretically, anode deletion would increase from year to year. Based on the results gathered, a difference of up to 20 percent was sometimes observed between the wastage recorded by the ROV compared to the detailed analysis. The data gathered from detailed anaylsis is more accurate as a few different type of measurements are taken by the divers as compared the estimation made based on the images viewed using ROV. According to the analysis of the available data, the average 2-5 percent wastage of the anodes per year.Wastage of 70 percent had been set by Petronas as the limit of service for an Anode. Any anode that exceeds 70 percent wastage will be replaced on the next operation planned for the jacket/platform.

Cathodic Protection survey is also measured on the Anodes as well as its top and bottom stub. A newly installed Anode will normally have a reading of between (-) 1000mV – (-) 1100mV. However, the CPS reading will decrease over the years to around (-) 980mV. As recommended by the Det Norske Veritas (DNV), the CPS value of the structures should be between (-) 800mV and (-) 1150mV. Any value smaller than (-) 1150mV is considered over-protection while any value larger than (-) 800mV is considered under-protection.

Following are the analysis of the Anode Inspection on each individual jacket based on the data collected. The data of a total of 5 jackets from Platform Field was provided by the Petronas Carigali Sabah Operations (SBO). The Jacket Inspections were done on the jackets based on SBO's maintenance planning. The information provided in the Inspection Reports are not standardised hence some of the required data were not available in some of the reports. This analysis was done based on the available data. The analysis is focused on the wastage/depletion of the Anodes placed on the jackets.

Three Jacket Inspections were done on PLATFORM-C which was in 1989, 1994 and 2002 and it is shown in Table 4.6. Based on the data acquired, the wastage percentage of the Anodes increased by around 10 percent from 1989 to 1994. This is an abnormal trend and it might have been caused by erroneous reading or equipment default when the data was recorded in 1989. The data recorded in 1994 is more dependable as more surveys had been done on the Anodes and detailed inspection was done on 3 selected anodes. From 1994 to 2002, the wastage percentage was increased by around 40 percent; from the original 10 – 20 percent to the current 50 – 60 percent. By 2002, most of the Anodes were approaching their designed working life of 70 percent wastage. Petronas is planning to replace the Anodes in another few years in order to ensure good cathodic protection on the structures.

Table 4.7: General Inspection on Platform Jacket-C on Anodes (PLATFORM-C)

Structure Identification	Structure function			Installed	
PLATFORM-C	Cluster Drilling			1/4/1976	
Date of Anode Inspection	ID	Top Stub (-mV)	Anode (-mV)	Bot Stub(-mV)	Depletion (%)
11Aug-28Oct 1989	BAN2	987	1031	995	25
	BAN3	983	1012	974	20
	BAN7	988	1021	985	25
	BAN18	976	1002	991	20
22-28 Aug 1994	BAN1				<10
	BAN2	988	1004	979	10
	BAN3				<20
	BAN4				<10
	BAN5	967		981	50
	BAN6				<10
	BAN7				<10
	BAN8				<10
	BAN9				<10
	BAN10				<20
	BAN11				<40
	BAN12				30
22-27 Mar 2002	BAN13				<20
	BAN14				50
	BAN15				<10
	BAN16				<20
	BAN17	945	1014	968	45
	BAN18				<20
22-27 Mar 2002	BAN2		983		60
	BAN6		988		75
	BAN15		980		60
	BAN16		989		60
	BAN17		974		50
	BAN18		980		60
	BAN2		983		60

Three Jacket Inspections were done on PLATFORM-D which was in 1989, 1994, and 2003 and tabulated in Table 4.7. Based on the data acquired, the wastage percentage of the Anodes increased by around 25 percent between 1989 and 1994 (5 years period). Only one Anode, BAN2 was done detailed inspection on both 1989 and 1994. The result shows that there is a wastage increment of 25 percent. Another further wastage increment of around 10 percent was recorded between 1994 and 2003 (9 years period). Three Anodes were replaced in 2003 as their wastage percentage exceeds the working limit of 70 percent. Those Anodes are BAN9, BAN10, and BAN14. The remaining Anodes have wastage of around 50 percent. These Anodes should be able to last for another 5 to 10 years according to the wastage trend of this jacket.

Table 4.8: General Inspection on Platform Jacket-D on Anodes (PLATFORM-D)

Structure Identification	Structure function			Installed		
PLATFORM-D	Cluster Drilling			Sep-76		
Date of Anode Inspection	ID	Top Stub (-mV)	Anode (-mV)	Bot Stub (-mV)	Depletion (%)	Comment
19 -25 Aug 1989	BAN2	973	1014	985	25	
	BAN3	981	1034	987	35	
	BAN9	1036	1008	977	35	
	BAN12	979	1014	978	35	
20 - 22Aug 1994	BAN1				50	
	BAN2	936	1027	958	50	
	BAN3				50	
	BAN4				50	
	BAN5				40	
	BAN6				50	
	BAN7	931	1041	928	40	
	BAN8				50	
	BAN9				65	
	BAN10				65	
	BAN11				60	
	BAN12				65	

	BAN13				40	
	BAN14				50	
	BAN15				40	
	BAN16	937		951	50	
	BAN17				40	
	BAN18				40	
24th Sept 2003	BAN1	957	989	959	60	
	BAN2				50	
	BAN3				50	
	BAN4				50	
	BAN5				50	
	BAN6				50	
	BAN7				50	
	BAN8	956	976	954	40	
	BAN9	946	986	948	75	Replaced due to more than 70% depleted
New Anode BAN9		1012	1042	980		
	BAN10				80	Replaced due to more than 70% depleted
New Anode BAN10		981	1015	970		
	BAN11				50	
	BAN12				50	
	BAN13				50	
	BAN14	0	0	0	100	Replaced due to more than 70% depleted
New Anode BAN14		1005	1028	991		
	BAN15				50	
	BAN16				50	
	BAN17				50	
	BAN18				50	

The Jacket Inspections were done on PLATFORM-E which was in 1986, 1991 and 2002 and displayed in Table 4.8. Based on the data acquired, the wastage percentage of the Anodes increased around 10% between 1986 and 1991 (5 years period). The result in 1986 is only based on general inspection using ROV hence the error margin is large. Two Anodes which are Ban10 and BAN18 were found missing during the inspections on year 1991. The wastage percentage increased around another 20 percent between 1991 and 2002 (11 years period). An operation to replace the four Anodes was conducted in 2003. The Anodes are BAN3, BAN6, BAN10, and BAN18. BAN3 and BAN6 were replaced due to wastage percentage exceed the working limit of 70 percent. New BAN10 and BAN18 were installed to replace the missing Anodes.

Table 4.9 General Inspection on Platform Jacket-E on Anodes (PLATFORM-E)

Structure Identification	Structure function			Installed		
PLATFORM-E	Cluster Drilling			Sep-76		
Date of Anode Inspection	ID	Top Stub (-mV)	Anode (-mV)	Bot Stub (-mV)	Depletion (%)	Comment
10 -16 Mar 1991	BAN1	959	987	970	30	
1st July 1991	BAN8	957	983	956	40	
	BAN10					Missing
	BAN17	957	971	968	30	
	BAN18					Missing
31 Mar -4 Apr 2002	BAN1				20	
	BAN2				20	
	BAN3		969		90	
Replaced on 2-3 Oct 2003		1027	1040	1009		
	BAN4				50	
	BAN5				60	
	BAN6		968		80	
Replaced on 2-3 Oct 2003		1023	1046	1013		
	BAN7				25	
	BAN8				40	
	BAN9				40	
	BAN10				Missing	
Replaced on 2-3 Oct 2003		1022	1044	1020		Replaced on 2-3 Oct 2003
	BAN11				40	

	BAN12				60	
	BAN13		956		10	
	BAN14				20	
	BAN15				25	
	BAN16		972		30	
	BAN17				10	
	BAN18				Missing	
Replaced on 2-3 Oct 2003		1025	1048	1010		Replaced on 2-3 Oct 2003

The Jacket Inspections were done on PLATFORM-F which was in 1994 and 2003 and tabulated in Table 4.9. Based on the data acquired, the wastage percentage of the Anodes increased around 20% between 1994 and 2003 (9 years period). There is no data on the earlier years. This might due to misplace of data or error during handling process of the data when Shell handed over to Petronas in the earlier years. According to the data shown in 2003, the wastage percentages of most of the Anodes are around 50 – 75 percent. However, this data is not accurate as it is only based on general inspection. The detailed inspection on the selected Anodes showed that the real wastage might defer quite a lot from the general inspection. Moreover, based on the detailed inspection, BAN4 and BAN6 have 60 percent wastage. This shows that some of the other anodes might have equal or more wastage and are approaching their designed working life of 70 percent wastage. These Anodes should be good for another 5 years and it is recommended that planning should be done to replace some of the depleted Anodes in order to ensure good cathodic protection on the structures.

Table 4.10:General Inspection on Platform Jacket-F on Anodes (PLATFORM-F)

Structure Identification	Structure function			Installed		
PLATFORM-F	Cluster Drilling			Aug-80		
Date of Anode Inspection	ID	Top Stub (-mV)	Anode (-mV)	Bot Stub (-mV)	Depletion (%)	Comment
16 - 20 Aug 1994	BAN1				40	
24 - 28 Aug 1994	BAN2				40	
5 - 6 Sep 1994	BAN3				<40	
16 - 20 Aug 1994	BAN4				50	
	BAN5	860	1040	870	20	
	BAN6				40	
	BAN7	890	887	900	10	
	BAN8				<40	
	BAN9				<40	
	BAN10				40	
	BAN11				40	
	BAN12				40	
	BAN13	928	1043	904	15	
	BAN14				40	
	BAN15				50	
	BAN16				40	
	BAN17				40	
	BAN18				40	
19 - 23 Sep 2003 and 8 Oct 2003	BAN1				50-75	
	BAN2				50-75	
	BAN3				50-75	
	BAN4	927	964	925	60	
	BAN5				50-75	
	BAN6	934	958	924	60	
	BAN7				50-75	
	BAN8				50-75	
	BAN9				50-75	
	BAN10				50-75	
	BAN11				50-75	
	BAN12	922	943	929	30	
	BAN13				50-75	

Table 4.11 General Inspection on Platform Jacket-G on Anodes (PLATFORM-G)

Structure Identification	Structure function			Installed		
PLATFORM-F	Cluster Drilling			Aug-80		
Date of Anode Inspection	ID	Top Stub (-mV)	Anode (-mV)	Bot Stub (-mV)	Depletion (%)	Comment
9-Mar-91	BAN9	919	972	916	25	
	BAN15	934	985	929	25	
	BAN3				Missing	
	BAN12				Missing	
	BAN18				Misplaced	
4 - 6 Apr 2002	BAN1				100	
	BAN2				95	
	BAN3				100	
	BAN4				100	
	BAN5				100	
	BAN6				90	
	BAN7		944		100	
	BAN8				100	
	BAN9				70	
	BAN10				85	
	BAN11				70	
	BAN12				95	
	BAN13				90	
	BAN14		881		90	
	BAN15				70	
	BAN16				30	
	BAN17		916		50	
	BAN18				70	

4.2 Experimental Phase

The corrosion coupons were fabricated and were attached to the frames. Figure 4.1 and Figure 4.2 showed the new corrosion coupons. The installation of the corrosion coupons were done on 30^{th} March 2010.

Figure 4.1: New coupons from Japan fabricator

Figure 4.2: New coupons from China fabricator.

Refer Attachment B: Process on the fabrication and installation of corrosion coupons and frames displayed in pictures.

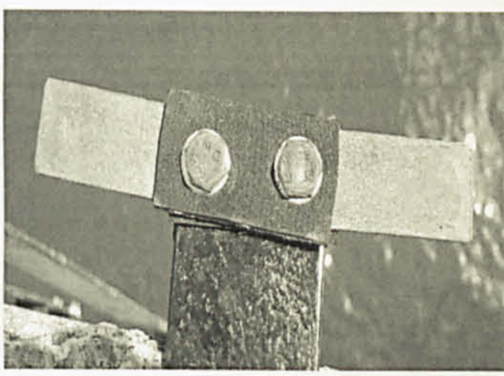

Figure 4.3: The coupons after 1 day of installation(China Fabricator)

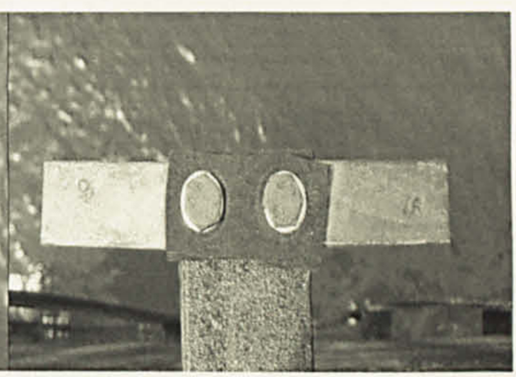

Figure 4.4: The coupons after 1 day of installation (Japan Fabricator)

4.2.1 Photo of The Experimental Set Up.

Figure 4.5: Experimental set up in Boustead Shipyard Sdn. Bhd

Attached in Appendix C: Schematic drawing of the experimental set up

Attached in Appendix D: Details of Tides in Lumut Perak Darul Ridzuan

Below are the informations on the experimental condition in the experimental phase:

Table 4.12 Experimental Conditions for Final Year Project

	Items	Unit	Specification
Electrolyte	Sample location		Natural Seawater
	Sampling location		Boustead Naval Shipyard Sdn. Bhd. Jetty Pangkalan TLDM Lumut, 32100 , Lumut Perak Malaysia
	pH		
	Salinity	%	
	Temperature		

***The pH, salinity and temperature will be taken on 29th June 2010 during the collection of corrosion samples.*

4.2.1 Calculate the Corrosion Rate as follows:

Mils per year (mpy)= (534x ΔW)/ A x T x D

Milimeters per year (mm/y) = 0.0254 x mpy

Where ΔW= Weight loss of coupon (mg)

A= Total Surface Area of coupon (in^2)

T= Exposure time (hrs)

D= Density of coupon (g/cm^3)

The physical appearance of the coupon will be observed for the presence of any pitting as well any other type of corrosion. The location of the corrosion is also noted.

Attached in Appendix E: The numbering and pre weight for each of the test coupons.

CHAPTER 5

CONCLUSION

The data for ultrasonic wall thickness for all the platforms was not fully available and hence no comparison could be made. General Inspection on jacket structure was done to obtain the cathodic potential measurement and most of the measurement were ranged between (-) 800mV to (-) 1200mV. Therefore the protection was adequate.

Besides that, the inspection history of platforms showed that most of the Anodes are approaching their designed working life of 70 percent wastage. Few anodes that exceeded 70% wastage have been replaced. Few anodes were reported missing in earlier analysis was seen in subsequent observation.

The test set up for determining corrosion rate has been installed at the Boustead Shipyard Sdn Bhd. The data will be collected every 3 months for the experiments of 3 years.

The reduction of corrosion allowance would mean that the steel structure can be continued to be used without strengthening. This project has the potential to reduce the cost for corrosion allowance. The implementation would benefit PETRONAS in terms of cost reduction during design and maintenance. To put it in a nutshell, the identification of the corrosion allowance that suit Malaysia condition is a need as it will signify large savings.

CHAPTER 6

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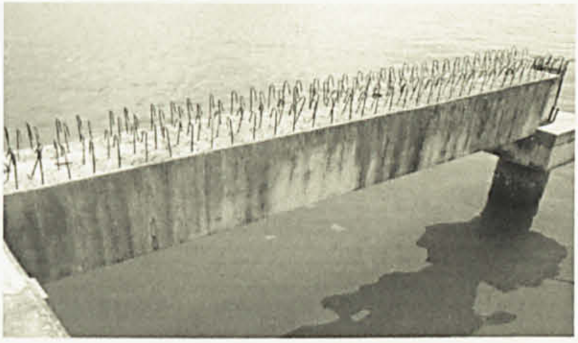
APPENDIX A

How to determine the salinity of the seawater?

1. Ensure your Electrical conductivity (EC) meter has been calibrated.
2. Remove the protective cap, switch the meter on and insert the probe into the water sample up to the immersion level.
3. Move the probe up and down to remove bubbles from around the electrodes. This will ensure good contact is achieved between water and electrodes (do not swirl it around as this may actually drive water out of the probe).
4. Allow the probe to reach the temperature of the water before taking a reading. Temperature has a significant impact on the salinity reading. EC units are standardized to a temperature of 25oC
5. If the meter has automatic temperature compensation, wait about 30 seconds before taking your reading if the water and probe are about the same temperature. If the water is much colder than the probe, allow longer period, say two minutes before taking a reading.
6. If the meter has no temperature compensation takes the temperature of the sample and uses a correction table to get the right value.
7. Read the display, and record the result. Rinse the probe with tank water and drain off any excess water, between each sample and at the end of sampling for the day. This will prevent false readings due to salt residues on the meter from the last sample.

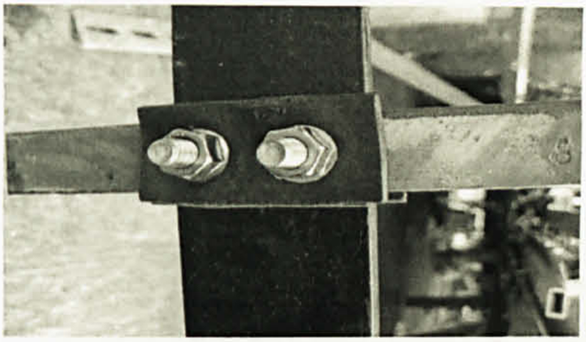
APPENDIX B

Process on the fabrication and installation of corrosion coupons and frames displayed in pictures.



The beam dimension was measured before fabricating the frames.

The first set of frame attached with corrosion coupons (as the control of the experiment) were installed on 24 March 2010 to ensure the dimension of the frames fit the beam.

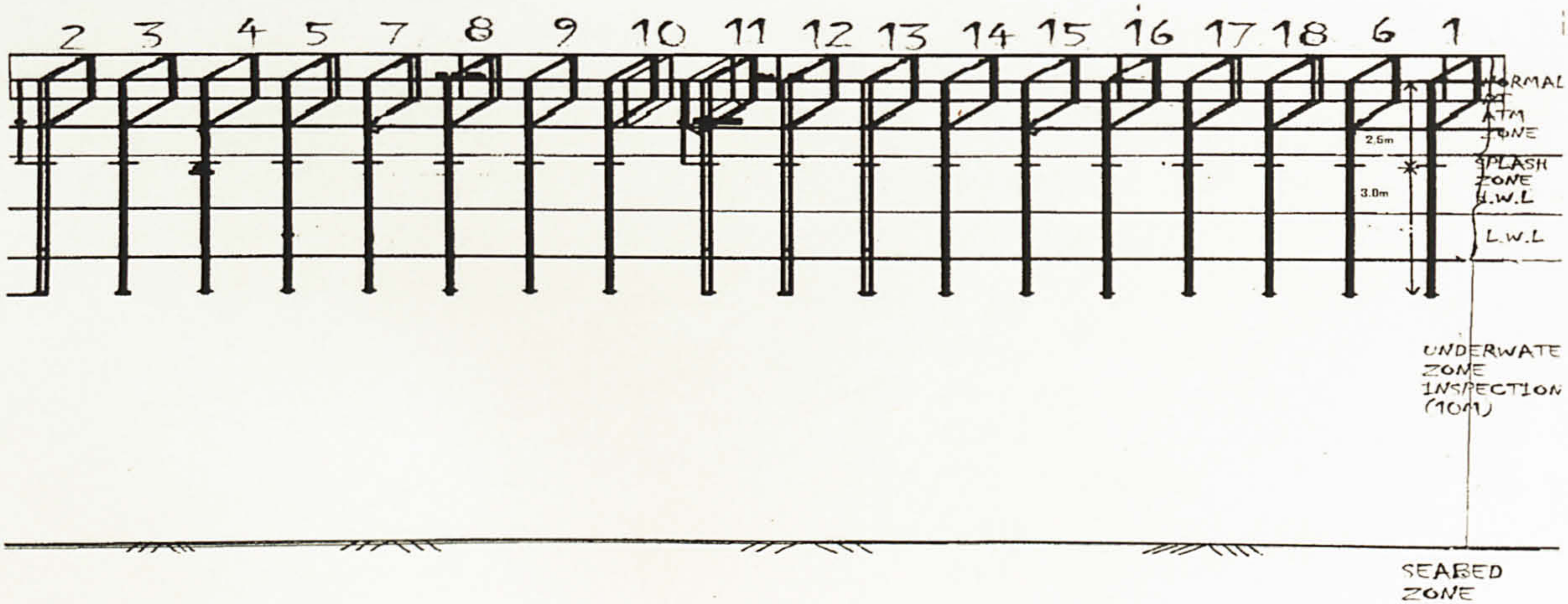


The rubber pads were used to separate the bolt and washes from the corrosion coupons to avoid galvanic corrosion.

The remaining 18 set of frames was installed on 29th March 2010.

The experimental set up is completed.

APPENDIX C: Schematic drawing of the experimental set up



APPENDIX D: Details of Tides in Lumut Perak Darul Ridzuan

LUMUT, PERAK DARUL RIDZUAN

YEAR 2010

Lat 04 14 N Long 100 37 E

TIME ZONE 0800 JANUARY HEIGHTS IN METRES

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1 F	1.5	2.0	2.5	2.8	3.0	2.9	2.5	1.9	1.3	0.8	0.4	0.3	0.6	1.1	1.7	2.3	2.6	2.8	2.7	2.4	1.9	1.5	1.1	1.0
2 Sa	1.1	1.6	2.2	2.6	3.0	3.1	2.9	2.4	1.8	1.1	0.6	0.3	0.2	0.6	1.3	1.9	2.4	2.8	2.9	2.8	2.4	1.9	1.4	1.1
3 Su	1.0	1.2	1.7	2.3	2.7	3.0	3.0	2.8	2.2	1.5	0.9	0.4	0.2	0.3	0.8	1.4	2.1	2.6	2.9	3.0	2.7	2.3	1.8	1.4
4 M	1.1	1.0	1.4	1.9	2.4	2.8	3.0	2.9	2.6	2.0	1.3	0.8	0.4	0.2	0.5	1.0	1.7	2.3	2.7	2.9	2.9	2.7	2.2	1.7
5 T	1.3	1.1	1.1	1.5	1.9	2.4	2.7	2.8	2.7	2.3	1.7	1.2	0.7	0.4	0.4	0.8	1.3	1.9	2.4	2.8	2.9	2.9	2.5	2.1
6 W	1.7	1.3	1.2	1.2	1.6	2.0	2.3	2.5	2.6	2.4	2.0	1.5	1.1	0.8	0.6	0.7	1.1	1.6	2.1	2.5	2.8	2.9	2.7	2.4
7 Th	2.0	1.6	1.3	1.2	1.3	1.6	1.9	2.1	2.3	2.3	2.1	1.8	1.5	1.2	1.0	0.9	1.0	1.4	1.8	2.2	2.5	2.7	2.7	2.6
8 F	2.3	1.9	1.6	1.4	1.3	1.4	1.5	1.8	2.0	2.1	2.1	2.0	1.8	1.5	1.3	1.2	1.2	1.3	1.6	1.9	2.2	2.5	2.6	2.6
9 Sa	2.4	2.2	1.9	1.6	1.4	1.3	1.3	1.4	1.6	1.8	1.9	2.0	1.9	1.8	1.7	1.5	1.4	1.4	1.5	1.7	1.9	2.1	2.3	2.4
10 Su	2.5	2.3	2.1	1.9	1.6	1.4	1.3	1.2	1.3	1.5	1.6	1.8	1.9	2.0	2.0	1.9	1.7	1.6	1.5	1.5	1.6	1.8	2.0	2.2
11 M	2.4	2.4	2.3	2.1	1.9	1.6	1.3	1.2	1.1	1.2	1.4	1.6	1.8	2.0	2.1	2.1	2.0	1.8	1.6	1.5	1.5	1.5	1.7	1.9
12 T	2.2	2.4	2.4	2.4	2.1	1.8	1.5	1.2	1.0	0.9	1.1	1.3	1.6	2.0	2.2	2.3	2.3	2.1	1.9	1.6	1.4	1.3	1.4	1.7
13 W	2.0	2.2	2.4	2.5	2.4	2.1	1.7	1.4	1.0	0.8	0.8	1.0	1.4	1.8	2.1	2.4	2.4	2.3	2.1	1.8	1.5	1.3	1.2	1.4
14 Th	1.7	2.1	2.4	2.6	2.6	2.4	2.0	1.6	1.1	0.8	0.7	0.7	1.1	1.5	2.0	2.3	2.5	2.5	2.3	2.0	1.6	1.3	1.2	1.2
15 F ●	1.5	1.9	2.3	2.6	2.7	2.6	2.3	1.8	1.3	0.9	0.6	0.6	0.8	1.2	1.7	2.2	2.4	2.6	2.5	2.2	1.8	1.5	1.2	1.1
16 Sa	1.3	1.7	2.1	2.5	2.7	2.8	2.5	2.1	1.6	1.1	0.7	0.5	0.6	1.0	1.5	2.0	2.3	2.6	2.6	2.4	2.0	1.6	1.3	1.1
17 Su	1.1	1.4	1.9	2.3	2.7	2.8	2.7	2.4	1.8	1.3	0.8	0.5	0.5	0.7	1.2	1.8	2.2	2.5	2.7	2.6	2.2	1.8	1.4	1.2
18 M	1.1	1.3	1.7	2.1	2.5	2.8	2.8	2.5	2.1	1.5	1.0	0.6	0.5	0.6	1.0	1.5	2.0	2.4	2.7	2.7	2.4	2.0	1.6	1.3
19 T	1.1	1.1	1.4	1.9	2.3	2.6	2.7	2.6	2.3	1.7	1.2	0.8	0.5	0.5	0.8	1.3	1.9	2.3	2.6	2.7	2.6	2.3	1.8	1.4
20 W	1.2	1.1	1.2	1.6	2.0	2.4	2.6	2.6	2.4	1.9	1.4	1.0	0.7	0.6	0.7	1.2	1.7	2.2	2.5	2.7	2.7	2.5	2.1	1.7
21 Th	1.3	1.1	1.1	1.4	1.8	2.1	2.4	2.5	2.4	2.1	1.6	1.2	0.9	0.7	0.7	1.0	1.5	2.0	2.4	2.6	2.7	2.6	2.3	1.9
22 F	1.5	1.3	1.1	1.2	1.5	1.8	2.1	2.3	2.3	2.2	1.8	1.5	1.1	0.9	0.8	1.0	1.3	1.8	2.1	2.4	2.6	2.6	2.4	2.1
23 Sa	1.7	1.5	1.3	1.2	1.3	1.6	1.8	2.1	2.2	2.1	2.0	1.7	1.4	1.2	1.0	1.0	1.2	1.5	1.9	2.2	2.4	2.5	2.4	2.3
24 Su	2.0	1.7	1.5	1.3	1.3	1.4	1.6	1.8	1.9	2.0	2.0	1.9	1.7	1.5	1.3	1.2	1.2	1.4	1.6	1.9	2.1	2.3	2.4	2.3
25 M	2.2	2.0	1.7	1.5	1.3	1.3	1.3	1.5	1.6	1.8	1.9	1.9	1.9	1.8	1.6	1.5	1.4	1.4	1.4	1.6	1.8	2.0	2.2	2.3
26 T	2.3	2.2	2.0	1.8	1.6	1.4	1.2	1.2	1.3	1.4	1.7	1.8	2.0	2.0	2.0	1.9	1.7	1.5	1.4	1.4	1.4	1.6	1.9	2.1
27 W	2.3	2.4	2.4	2.2	1.9	1.6	1.3	1.1	1.0	1.0	1.3	1.6	1.9	2.1	2.2	2.2	2.1	1.8	1.6	1.4	1.2	1.3	1.5	1.8
28 Th	2.1	2.4	2.6	2.5	2.3	1.9	1.5	1.1	0.8	0.7	0.8	1.1	1.6	2.0	2.3	2.5	2.5	2.2	1.9	1.5	1.2	1.1	1.1	1.4
29 F	1.9	2.3	2.6	2.8	2.7	2.4	1.9	1.3	0.9	0.5	0.4	0.6	1.1	1.7	2.1	2.5	2.7	2.6	2.3	1.9	1.5	1.1	0.9	1.0
30 Sa ○	1.4	2.0	2.5	2.8	2.9	2.8	2.4	1.7	1.1	0.6	0.2	0.2	0.6	1.2	1.8	2.4	2.7	2.9	2.8	2.3	1.8	1.3	1.0	0.8
31 Su	1.0	1.5	2.1	2.6	3.0	3.0	2.8	2.2	1.5	0.9	0.3	0.0	0.1	0.7	1.4	2.0	2.6	2.9	3.0	2.8	2.3	1.7	1.2	0.9

TIME ZONE ·0800 FEBRUARY HEIGHTS IN METRES

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1 M	0.8	1.1	1.7	2.3	2.8	3.0	3.0	2.6	2.0	1.3	0.6	0.2	0.0	0.3	0.9	1.6	2.3	2.8	3.1	3.0	2.7	2.1	1.5	1.1
2 T	0.8	0.8	1.3	1.8	2.4	2.8	2.9	2.8	2.4	1.7	1.1	0.5	0.2	0.1	0.6	1.2	1.9	2.5	2.9	3.1	2.9	2.5	1.9	1.4
3 W	1.0	0.8	1.0	1.4	1.9	2.4	2.7	2.8	2.6	2.1	1.5	0.9	0.5	0.3	0.5	1.0	1.6	2.2	2.7	2.9	3.0	2.7	2.2	1.7
4 Th	1.3	0.9	0.9	1.1	1.5	2.0	2.3	2.5	2.5	2.3	1.8	1.3	0.9	0.6	0.6	0.9	1.4	1.9	2.4	2.7	2.9	2.8	2.4	2.0
5 F	1.5	1.2	1.0	1.0	1.3	1.6	2.0	2.2	2.3	2.2	2.0	1.6	1.3	1.0	0.9	0.9	1.2	1.7	2.1	2.4	2.6	2.6	2.5	2.1
6 Sa	1.8	1.5	1.2	1.1	1.2	1.4	1.6	1.9	2.0	2.1	2.0	1.8	1.6	1.4	1.2	1.2	1.3	1.5	1.8	2.1	2.3	2.4	2.4	2.2
7 Su	2.0	1.7	1.5	1.3	1.2	1.3	1.4	1.6	1.7	1.8	1.9	1.9	1.8	1.7	1.6	1.5	1.4	1.5	1.6	1.8	2.0	2.1	2.2	2.2
8 M	2.1	1.9	1.7	1.5	1.4	1.3	1.3	1.3	1.4	1.6	1.7	1.8	1.9	1.9	1.8	1.8	1.7	1.6	1.6	1.6	1.7	1.8	1.9	2.0
9 T	2.1	2.1	2.0	1.8	1.6	1.5	1.3	1.2	1.2	1.3	1.5	1.7	1.8	2.0	2.1	2.0	1.9	1.8	1.6	1.5	1.4	1.5	1.6	1.8
10 W	2.0	2.1	2.2	2.1	1.9	1.7	1.4	1.2	1.1	1.0	1.2	1.4	1.7	2.0	2.2	2.2	2.2	2.0	1.8	1.5	1.4	1.3	1.3	1.6
11 Th	1.8	2.1	2.3	2.3	2.2	1.9	1.6	1.3	1.0	0.9	0.9	1.1	1.5	1.8	2.1	2.3	2.4	2.3	2.0	1.7	1.4	1.2	1.1	1.3
12 F	1.6	2.0	2.3	2.4	2.4	2.2	1.8	1.4	1.1	0.8	0.7	0.8	1.2	1.7	2.1	2.4	2.5	2.5	2.2	1.8	1.5	1.2	1.0	1.1
13 Sa	1.4	1.9	2.2	2.5	2.6	2.5	2.1	1.6	1.2	0.8	0.6	0.6	0.9	1.4	1.9	2.3	2.5	2.6	2.4	2.1	1.6	1.3	1.0	1.0
14 Su ●	1.2	1.7	2.1	2.5	2.7	2.7	2.4	1.9	1.3	0.9	0.5	0.4	0.6	1.1	1.7	2.2	2.5	2.7	2.6	2.3	1.8	1.4	1.1	0.9
15 M	1.0	1.4	1.9	2.4	2.7	2.8	2.6	2.1	1.6	1.0	0.6	0.4	0.5	0.9	1.4	2.0	2.4	2.7	2.8	2.5	2.1	1.6	1.2	0.9
16 T	0.9	1.2	1.7	2.2	2.6	2.7	2.7	2.4	1.8	1.3	0.8	0.5	0.4	0.7	1.2	1.8	2.3	2.7	2.8	2.7	2.3	1.8	1.3	1.0
17 W	0.8	1.0	1.4	1.9	2.4	2.6	2.7	2.5	2.1	1.5	1.0	0.6	0.4	0.6	1.0	1.6	2.2	2.6	2.8	2.8	2.5	2.0	1.5	1.1
18 Th	0.8	0.8	1.2	1.6	2.1	2.5	2.6	2.6	2.2	1.7	1.2	0.8	0.6	0.5	0.9	1.4	2.0	2.4	2.7	2.8	2.7	2.2	1.7	1.3
19 F	1.0	0.8	1.0	1.4	1.8	2.2	2.5	2.5	2.3	1.9	1.5	1.0	0.7	0.6	0.8	1.2	1.8	2.2	2.6	2.7	2.7	2.4	1.9	1.5
20 Sa	1.1	0.9	0.9	1.2	1.6	2.0	2.2	2.4	2.3	2.1	1.7	1.3	1.0	0.8	0.8	1.1	1.6	2.0	2.4	2.6	2.6	2.5	2.1	1.7
21 Su	1.4	1.1	1.0	1.1	1.3	1.7	2.0	2.2	2.2	2.1	1.9	1.5	1.3	1.1	1.0	1.1	1.4	1.7	2.1	2.3	2.5	2.4	2.2	1.9
22 M	1.6	1.3	1.2	1.1	1.2	1.4	1.7	1.9	2.1	2.1	2.0	1.8	1.6	1.4	1.3	1.2	1.3	1.5	1.8	2.0	2.2	2.3	2.2	2.1
23 T	1.9	1.7	1.4	1.3	1.2	1.3	1.4	1.6	1.8	1.9	2.0	1.9	1.9	1.7	1.6	1.5	1.4	1.4	1.5	1.7	1.8	2.0	2.1	2.1
24 W	2.1	2.0	1.8	1.6	1.4	1.3	1.2	1.2	1.4	1.5	1.7	1.9	2.0	2.0	2.0	1.9	1.7	1.5	1.4	1.4	1.5	1.6	1.9	2.0
25 Th	2.2	2.2	2.2	2.0	1.7	1.4	1.2	1.0	1.0	1.1	1.4	1.7	2.0	2.2	2.3	2.3	2.1	1.8	1.6	1.3	1.2	1.3	1.5	1.8
26 F	2.1	2.4	2.5	2.4	2.1	1.8	1.3	1.0	0.7	0.7	0.9	1.3	1.7	2.1	2.4	2.6	2.5	2.3	1.9	1.5	1.2	1.0	1.1	1.4
27 Sa	1.9	2.3	2.6	2.7	2.6	2.2	1.7	1.2	0.7	0.4	0.4	0.7	1.3	1.9	2.4	2.7	2.8	2.7	2.3	1.8	1.3	1.0	0.8	1.0
28 Su	1.5	2.0	2.5	2.8	2.9	2.7	2.2	1.5	0.9	0.4	0.2	0.3	0.8	1.5	2.1	2.6	3.0	3.0	2.8	2.2	1.7	1.2	0.8	0.7

LUMUT, PERAK DARUL RIDZUAN

YEAR 2010 — Lat 04 14 N Long 100 37 E

TIME ZONE -0800 — **MARCH** — HEIGHTS IN METRES

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1 M ○	1.0	1.6	2.2	2.7	2.9	2.9	2.6	2.0	1.3	0.7	0.2	0.1	0.3	1.0	1.7	2.4	2.9	3.1	3.1	2.7	2.1	1.5	1.0	0.6
2 T	0.7	1.1	1.8	2.3	2.8	3.0	2.9	2.4	1.8	1.1	0.5	0.1	0.1	0.6	1.3	2.0	2.6	3.0	3.2	3.0	2.5	1.8	1.2	0.8
3 W	0.6	0.8	1.3	1.9	2.4	2.8	2.9	2.7	2.2	1.5	0.9	0.4	0.2	0.4	1.0	1.7	2.3	2.8	3.1	3.1	2.7	2.2	1.5	1.0
4 Th	0.7	0.6	0.9	1.5	2.0	2.5	2.7	2.7	2.4	1.9	1.3	0.8	0.5	0.5	0.8	1.4	2.0	2.5	2.9	3.0	2.8	2.4	1.8	1.3
5 F	0.9	0.7	0.8	1.2	1.7	2.1	2.4	2.5	2.5	2.1	1.7	1.2	0.9	0.7	0.8	1.2	1.7	2.2	2.6	2.8	2.8	2.5	2.0	1.6
6 Sa	1.2	0.9	0.8	1.0	1.4	1.8	2.1	2.3	2.3	2.2	1.9	1.5	1.2	1.0	1.0	1.2	1.6	1.9	2.3	2.5	2.6	2.4	2.1	1.7
7 Su	1.4	1.1	1.0	1.0	1.2	1.5	1.8	2.0	2.1	2.1	2.0	1.7	1.5	1.4	1.3	1.3	1.5	1.7	2.0	2.2	2.3	2.3	2.1	1.9
8 M	1.6	1.4	1.2	1.2	1.2	1.4	1.6	1.7	1.9	2.0	2.0	1.9	1.8	1.7	1.6	1.5	1.5	1.6	1.8	1.9	2.0	2.0	2.0	1.9
9 T	1.8	1.7	1.5	1.4	1.4	1.4	1.4	1.5	1.6	1.7	1.8	1.9	1.9	1.9	1.8	1.8	1.7	1.6	1.6	1.6	1.7	1.8	1.8	1.9
10 W	1.9	1.9	1.8	1.7	1.5	1.4	1.4	1.3	1.4	1.5	1.6	1.8	1.9	2.0	2.1	2.0	1.9	1.8	1.6	1.5	1.4	1.5	1.6	1.8
11 Th	1.9	2.0	2.0	1.9	1.8	1.6	1.4	1.2	1.2	1.2	1.4	1.6	1.9	2.1	2.3	2.3	2.2	2.0	1.7	1.5	1.3	1.3	1.4	1.6
12 F	1.8	2.1	2.2	2.2	2.1	1.8	1.5	1.2	1.0	1.0	1.1	1.4	1.7	2.1	2.3	2.5	2.4	2.2	1.9	1.6	1.3	1.1	1.2	1.4
13 Sa	1.7	2.0	2.3	2.4	2.3	2.0	1.7	1.3	1.0	0.8	0.8	1.1	1.5	2.0	2.3	2.6	2.6	2.4	2.1	1.7	1.4	1.1	1.0	1.2
14 Su	1.6	2.0	2.3	2.5	2.5	2.3	1.9	1.4	1.0	0.7	0.6	0.8	1.3	1.8	2.2	2.6	2.7	2.7	2.3	1.9	1.5	1.1	0.9	1.0
15 M ●	1.3	1.8	2.2	2.5	2.6	2.5	2.2	1.7	1.2	0.8	0.6	0.6	1.0	1.5	2.1	2.5	2.8	2.8	2.6	2.1	1.6	1.2	0.9	0.8
16 T	1.1	1.6	2.1	2.4	2.7	2.7	2.4	1.9	1.4	0.9	0.6	0.5	0.8	1.3	1.9	2.4	2.7	2.9	2.8	2.4	1.8	1.3	0.9	0.7
17 W	0.8	1.3	1.8	2.3	2.6	2.7	2.6	2.2	1.6	1.1	0.7	0.5	0.6	1.1	1.7	2.2	2.7	2.9	2.9	2.6	2.1	1.5	1.0	0.7
18 Th	0.7	1.0	1.5	2.0	2.4	2.7	2.7	2.4	1.9	1.4	0.9	0.6	0.6	0.9	1.4	2.0	2.5	2.8	2.9	2.8	2.3	1.7	1.2	0.8
19 F	0.6	0.8	1.2	1.8	2.2	2.5	2.6	2.5	2.1	1.6	1.2	0.8	0.6	0.8	1.2	1.8	2.3	2.7	2.9	2.8	2.5	2.0	1.4	1.0
20 Sa	0.7	0.7	1.0	1.5	2.0	2.3	2.5	2.5	2.3	1.9	1.4	1.0	0.8	0.8	1.1	1.6	2.1	2.5	2.7	2.8	2.6	2.2	1.7	1.2
21 Su	0.9	0.7	0.9	1.2	1.7	2.1	2.3	2.5	2.4	2.1	1.7	1.3	1.0	0.9	1.0	1.4	1.8	2.2	2.5	2.7	2.6	2.3	1.9	1.5
22 M	1.1	0.9	0.9	1.1	1.4	1.8	2.1	2.3	2.3	2.2	1.9	1.6	1.3	1.2	1.1	1.3	1.6	1.9	2.2	2.4	2.5	2.4	2.1	1.8
23 T	1.4	1.2	1.1	1.1	1.3	1.5	1.8	2.0	2.2	2.2	2.1	1.9	1.7	1.5	1.4	1.3	1.5	1.7	1.9	2.1	2.2	2.3	2.2	2.0
24 W	1.8	1.5	1.3	1.2	1.2	1.3	1.5	1.7	1.9	2.0	2.1	2.1	2.0	1.9	1.7	1.6	1.5	1.5	1.6	1.7	1.9	2.0	2.1	2.1
25 Th	2.1	1.9	1.7	1.5	1.3	1.2	1.2	1.3	1.5	1.7	1.9	2.1	2.2	2.2	2.1	2.0	1.8	1.6	1.5	1.5	1.5	1.7	1.9	2.1
26 F	2.2	2.2	2.1	1.9	1.6	1.3	1.1	1.0	1.0	1.3	1.6	1.9	2.2	2.4	2.5	2.4	2.2	1.9	1.6	1.3	1.2	1.3	1.6	1.9
27 Sa	2.2	2.4	2.4	2.3	2.0	1.6	1.2	0.9	0.7	0.8	1.1	1.6	2.1	2.5	2.7	2.8	2.6	2.3	1.9	1.4	1.1	1.0	1.2	1.5
28 Su	2.0	2.3	2.6	2.6	2.4	2.0	1.5	1.0	0.7	0.5	0.7	1.1	1.7	2.3	2.7	3.0	3.0	2.7	2.2	1.7	1.2	0.9	0.8	1.1
29 M	1.6	2.1	2.5	2.7	2.8	2.5	1.9	1.4	0.8	0.5	0.4	0.7	1.3	1.9	2.5	2.9	3.2	3.1	2.6	2.1	1.5	1.0	0.7	0.7
30 T ○	1.1	1.7	2.3	2.7	2.9	2.8	2.4	1.8	1.2	0.7	0.4	0.4	0.8	1.5	2.2	2.8	3.1	3.2	3.0	2.4	1.8	1.2	0.7	0.5
31 W	0.7	1.3	1.9	2.4	2.8	2.9	2.7	2.2	1.6	1.0	0.6	0.4	0.6	1.1	1.8	2.5	2.9	3.2	3.2	2.8	2.1	1.5	0.9	0.6

TIME ZONE -0800 — **APRIL** — HEIGHTS IN METRES

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1 Th	0.5	0.9	1.4	2.0	2.5	2.8	2.8	2.5	2.0	1.4	0.9	0.6	0.6	0.9	1.5	2.1	2.7	3.0	3.1	2.9	2.4	1.8	1.2	0.8
2 F	0.5	0.6	1.1	1.6	2.2	2.5	2.7	2.6	2.3	1.8	1.3	1.0	0.7	0.8	1.3	1.8	2.4	2.8	3.0	2.9	2.6	2.0	1.5	1.0
3 Sa	0.7	0.6	0.9	1.3	1.8	2.2	2.5	2.6	2.4	2.1	1.7	1.3	1.0	1.0	1.2	1.6	2.1	2.5	2.7	2.8	2.6	2.2	1.7	1.3
4 Su	1.0	0.8	0.8	1.2	1.6	1.9	2.2	2.4	2.4	2.2	1.9	1.6	1.3	1.2	1.2	1.5	1.8	2.2	2.4	2.6	2.5	2.3	1.9	1.5
5 M	1.2	1.0	1.0	1.1	1.4	1.7	2.0	2.2	2.3	2.2	2.0	1.8	1.6	1.5	1.4	1.5	1.7	1.9	2.1	2.3	2.3	2.2	2.0	1.7
6 T	1.5	1.3	1.2	1.2	1.3	1.5	1.8	2.0	2.1	2.1	2.1	2.0	1.8	1.7	1.6	1.6	1.6	1.8	1.9	2.0	2.1	2.1	2.0	1.9
7 W	1.7	1.6	1.4	1.4	1.4	1.5	1.6	1.7	1.9	2.0	2.1	2.1	2.0	2.0	1.9	1.8	1.7	1.7	1.7	1.7	1.8	1.9	1.9	1.9
8 Th	1.9	1.8	1.7	1.6	1.5	1.4	1.4	1.5	1.6	1.8	1.9	2.1	2.2	2.2	2.1	2.0	1.9	1.7	1.6	1.6	1.6	1.6	1.8	1.9
9 F	2.0	2.0	1.9	1.8	1.7	1.5	1.4	1.3	1.4	1.5	1.8	2.0	2.2	2.3	2.4	2.3	2.1	1.9	1.6	1.5	1.4	1.4	1.6	1.8
10 Sa	2.0	2.1	2.2	2.1	1.9	1.6	1.4	1.2	1.2	1.3	1.5	1.6	2.1	2.4	2.6	2.5	2.4	2.1	1.8	1.5	1.3	1.2	1.4	1.6
11 Su	1.9	2.1	2.3	2.3	2.1	1.8	1.5	1.2	1.1	1.0	1.2	1.6	2.0	2.4	2.6	2.7	2.6	2.3	1.9	1.6	1.2	1.1	1.1	1.4
12 M	1.8	2.1	2.4	2.5	2.4	2.1	1.7	1.3	1.0	0.9	1.0	1.3	1.8	2.2	2.6	2.8	2.8	2.6	2.2	1.7	1.3	1.0	0.9	1.1
13 T	1.5	2.0	2.3	2.5	2.6	2.4	2.0	1.5	1.1	0.9	0.8	1.1	1.5	2.1	2.5	2.8	2.9	2.8	2.4	1.9	1.4	1.0	0.8	0.9
14 W ●	1.3	1.8	2.2	2.5	2.7	2.6	2.2	1.8	1.3	0.9	0.8	0.9	1.3	1.8	2.3	2.7	3.0	3.0	2.7	2.1	1.6	1.1	0.8	0.7
15 Th	1.0	1.5	2.0	2.4	2.7	2.7	2.5	2.1	1.6	1.1	0.8	0.8	1.0	1.6	2.1	2.6	2.9	3.0	2.9	2.4	1.8	1.3	0.9	0.6
16 F	0.7	1.1	1.7	2.2	2.5	2.7	2.7	2.3	1.8	1.4	1.0	0.8	0.9	1.3	1.9	2.4	2.8	3.0	3.0	2.6	2.1	1.5	1.0	0.7
17 Sa	0.6	0.9	1.4	1.9	2.3	2.6	2.7	2.5	2.1	1.7	1.2	1.0	0.9	1.1	1.6	2.1	2.6	2.9	3.0	2.8	2.4	1.8	1.3	0.9
18 Su	0.7	0.7	1.1	1.6	2.1	2.4	2.6	2.6	2.3	1.9	1.5	1.2	1.0	1.0	1.4	1.9	2.3	2.7	2.9	2.8	2.6	2.1	1.6	1.1
19 M	0.8	0.7	0.9	1.3	1.8	2.2	2.4	2.5	2.4	2.2	1.8	1.5	1.2	1.1	1.3	1.6	2.0	2.4	2.6	2.7	2.6	2.3	1.9	1.4
20 T	1.1	0.9	0.9	1.1	1.5	1.9	2.2	2.4	2.5	2.3	2.1	1.8	1.6	1.4	1.3	1.5	1.8	2.1	2.3	2.5	2.6	2.4	2.1	1.8
21 W	1.4	1.2	1.0	1.0	1.3	1.6	1.9	2.1	2.3	2.4	2.3	2.1	1.9	1.7	1.6	1.5	1.6	1.8	2.0	2.2	2.3	2.4	2.3	2.0
22 Th	1.8	1.5	1.3	1.2	1.1	1.3	1.5	1.8	2.0	2.2	2.4	2.4	2.3	2.1	1.9	1.7	1.6	1.6	1.7	1.8	2.0	2.2	2.2	2.2
23 F	2.1	1.9	1.6	1.4	1.2	1.2	1.2	1.4	1.7	2.0	2.2	2.4	2.5	2.5	2.3	2.1	1.8	1.6	1.5	1.5	1.6	1.8	2.0	2.2
24 Sa	2.3	2.2	2.0	1.8	1.5	1.2	1.1	1.1	1.3	1.6	2.0	2.3	2.6	2.7	2.7	2.5	2.2	1.9	1.5	1.3	1.3	1.4	1.7	2.0
25 Su	2.3	2.4	2.4	2.2	1.9	1.5	1.2	1.0	0.9	1.2	1.6	2.0	2.5	2.8	2.9	2.9	2.6	2.2	1.7	1.3	1.1	1.1	1.3	1.7
26 M	2.1	2.4	2.5	2.5	2.3	1.9	1.4	1.1	0.8	0.8	1.1	1.6	2.2	2.7	3.0	3.1	3.0	2.6	2.0	1.5	1.1	0.9	0.9	1.3
27 T	1.7	2.2	2.5	2.7	2.6	2.3	1.8	1.3	1.0	0.8	0.8	1.2	1.8	2.4	2.9	3.1	3.2	2.9	2.4	1.8	1.3	0.9	0.7	0.9
28 W	1.3	1.9	2.3	2.6	2.8	2.6	2.2	1.7	1.2	0.9	0.8	0.9	1.4	2.1	2.6	3.0	3.2	3.1	2.7	2.1	1.5	1.0	0.7	0.6
29 Th ○	0.9	1.5	2.0	2.5	2.7	2.8	2.6	2.1	1.6	1.2	0.9	0.8	1.1	1.7	2.3	2.8	3.1	3.1	2.9	2.4	1.8	1.3	0.8	0.6
30 F	0.6	1.1	1.6	2.2	2.5	2.8	2.7	2.4	2.0	1.5	1.1	0.9	1.0	1.4	2.0	2.5	2.8	3.1	3.0	2.7	2.1	1.5	1.0	0.7

LUMUT, PERAK DARUL RIDZUAN

YEAR 2010

Lat 04 14 N Long 100 37 E

TIME ZONE -0800 MAY HEIGHTS IN METRES

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1 Sa	0.6	0.8	1.3	1.8	2.3	2.6	2.7	2.6	2.3	1.8	1.4	1.2	1.1	1.2	1.7	2.2	2.6	2.9	2.9	2.8	2.4	1.8	1.3	0.9
2 Su	0.7	0.7	1.1	1.5	2.0	2.4	2.6	2.6	2.4	2.1	1.7	1.4	1.2	1.2	1.5	1.9	2.3	2.6	2.8	2.8	2.5	2.0	1.6	1.2
3 M	0.9	0.8	1.0	1.3	1.8	2.1	2.4	2.5	2.5	2.2	2.0	1.7	1.4	1.3	1.4	1.7	2.1	2.4	2.6	2.6	2.5	2.2	1.8	1.4
4 T	1.2	1.0	1.0	1.2	1.6	1.9	2.2	2.4	2.4	2.3	2.1	1.9	1.7	1.5	1.5	1.6	1.8	2.1	2.3	2.4	2.4	2.3	2.0	1.7
5 W	1.4	1.2	1.1	1.2	1.4	1.7	2.0	2.2	2.3	2.3	2.3	2.1	1.9	1.8	1.6	1.6	1.7	1.9	2.0	2.2	2.3	2.2	2.1	1.9
6 Th	1.7	1.5	1.3	1.3	1.4	1.5	1.8	2.0	2.2	2.3	2.3	2.3	2.2	2.0	1.9	1.7	1.7	1.7	1.8	1.9	2.0	2.1	2.1	2.0
7 F	1.9	1.7	1.5	1.4	1.4	1.4	1.6	1.8	2.0	2.2	2.3	2.4	2.4	2.3	2.1	1.9	1.8	1.7	1.7	1.7	1.8	1.9	2.0	2.0
8 Sa	2.0	1.9	1.8	1.6	1.5	1.4	1.4	1.5	1.7	2.0	2.2	2.4	2.5	2.5	2.4	2.2	2.0	1.7	1.6	1.5	1.5	1.7	1.8	2.0
9 Su	2.1	2.1	2.0	1.9	1.7	1.5	1.4	1.4	1.5	1.7	2.0	2.3	2.5	2.6	2.6	2.5	2.2	1.9	1.6	1.4	1.3	1.4	1.6	1.9
10 M	2.1	2.2	2.2	2.1	1.9	1.7	1.4	1.3	1.3	1.4	1.7	2.1	2.4	2.7	2.8	2.7	2.4	2.1	1.7	1.4	1.2	1.2	1.4	1.7
11 T	2.0	2.2	2.4	2.4	2.2	1.9	1.6	1.3	1.2	1.2	1.5	1.9	2.3	2.6	2.8	2.9	2.7	2.3	1.9	1.5	1.2	1.0	1.1	1.4
12 W	1.8	2.1	2.4	2.5	2.5	2.2	1.8	1.5	1.2	1.1	1.2	1.6	2.0	2.5	2.8	2.9	2.9	2.6	2.1	1.6	1.2	0.9	0.8	1.1
13 Th	1.5	2.0	2.3	2.6	2.6	2.5	2.1	1.7	1.3	1.1	1.1	1.3	1.7	2.2	2.6	2.9	3.0	2.8	2.4	1.9	1.4	1.0	0.7	0.8
14 F ●	1.2	1.7	2.1	2.5	2.7	2.7	2.4	2.0	1.6	1.2	1.0	1.1	1.4	2.0	2.4	2.8	3.0	3.0	2.7	2.2	1.6	1.1	0.8	0.6
15 Sa	0.8	1.3	1.9	2.3	2.6	2.7	2.6	2.3	1.9	1.4	1.1	1.0	1.2	1.7	2.2	2.6	2.9	3.1	2.9	2.5	1.9	1.4	0.9	0.6
16 Su	0.6	1.0	1.5	2.0	2.4	2.7	2.7	2.5	2.2	1.7	1.4	1.1	1.1	1.4	1.9	2.4	2.7	3.0	3.0	2.8	2.3	1.7	1.2	0.8
17 M	0.6	0.7	1.2	1.7	2.2	2.5	2.7	2.7	2.4	2.1	1.7	1.3	1.2	1.2	1.6	2.0	2.5	2.8	3.0	2.9	2.6	2.1	1.5	1.1
18 T	0.8	0.7	0.9	1.3	1.8	2.2	2.5	2.7	2.6	2.4	2.0	1.7	1.4	1.3	1.4	1.7	2.1	2.5	2.7	2.8	2.7	2.3	1.9	1.4
19 W	1.1	0.8	0.8	1.1	1.5	1.9	2.3	2.5	2.7	2.6	2.3	2.0	1.7	1.5	1.4	1.5	1.8	2.1	2.4	2.6	2.7	2.5	2.2	1.8
20 Th	1.4	1.1	0.9	1.0	1.2	1.6	2.0	2.3	2.5	2.6	2.6	2.4	2.1	1.8	1.6	1.5	1.6	1.8	2.1	2.3	2.5	2.5	2.3	2.1
21 F	1.7	1.4	1.2	1.0	1.1	1.3	1.6	2.0	2.3	2.6	2.7	2.6	2.5	2.2	2.0	1.7	1.6	1.6	1.7	1.9	2.1	2.3	2.3	2.3
22 Sa	2.1	1.8	1.5	1.3	1.1	1.1	1.3	1.6	2.0	2.3	2.6	2.8	2.7	2.6	2.3	2.0	1.8	1.5	1.5	1.6	1.7	2.0	2.2	2.3
23 Su	2.3	2.1	1.9	1.6	1.4	1.2	1.2	1.3	1.6	2.0	2.3	2.7	2.8	2.9	2.7	2.4	2.0	1.7	1.4	1.3	1.4	1.6	1.8	2.1
24 M	2.3	2.3	2.2	2.0	1.7	1.4	1.2	1.2	1.3	1.6	2.0	2.4	2.7	2.9	2.9	2.7	2.4	2.0	1.6	1.3	1.1	1.2	1.5	1.8
25 T	2.1	2.4	2.5	2.4	2.1	1.8	1.5	1.2	1.1	1.3	1.6	2.1	2.5	2.8	3.0	3.0	2.7	2.3	1.8	1.4	1.1	0.9	1.1	1.4
26 W	1.9	2.2	2.5	2.6	2.5	2.2	1.8	1.4	1.2	1.1	1.3	1.7	2.2	2.6	2.9	3.0	2.9	2.6	2.1	1.6	1.1	0.9	0.8	1.1
27 Th	1.5	2.0	2.3	2.6	2.7	2.5	2.2	1.8	1.4	1.2	1.1	1.4	1.8	2.3	2.7	3.0	3.0	2.8	2.4	1.9	1.3	0.9	0.7	0.8
28 F	1.1	1.6	2.1	2.5	2.7	2.7	2.5	2.1	1.7	1.4	1.2	1.2	1.5	2.0	2.5	2.8	3.0	3.0	2.7	2.2	1.6	1.1	0.8	0.7
29 Sa ○	0.8	1.3	1.8	2.2	2.6	2.7	2.7	2.4	2.0	1.6	1.3	1.2	1.3	1.7	2.2	2.6	2.9	3.0	2.8	2.4	1.9	1.4	1.0	0.7
30 Su	0.7	1.0	1.5	2.0	2.4	2.6	2.7	2.6	2.2	1.9	1.5	1.3	1.3	1.5	1.9	2.3	2.7	2.9	2.9	2.6	2.2	1.7	1.2	0.9
31 M	0.7	0.8	1.2	1.7	2.1	2.4	2.6	2.6	2.4	2.1	1.7	1.5	1.3	1.4	1.7	2.1	2.5	2.7	2.8	2.7	2.4	1.9	1.5	1.1

TIME ZONE -0800 JUNE HEIGHTS IN METRES

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1 T	0.9	0.8	1.1	1.5	1.9	2.3	2.5	2.6	2.5	2.3	2.0	1.7	1.5	1.4	1.5	1.9	2.2	2.5	2.7	2.7	2.5	2.2	1.7	1.3
2 W	1.1	0.9	1.0	1.3	1.7	2.1	2.4	2.5	2.6	2.4	2.2	1.9	1.6	1.5	1.5	1.7	2.0	2.3	2.5	2.6	2.5	2.3	1.9	1.6
3 Th	1.3	1.1	1.0	1.2	1.5	1.9	2.2	2.4	2.6	2.5	2.4	2.1	1.9	1.7	1.6	1.6	1.8	2.0	2.2	2.4	2.4	2.3	2.1	1.8
4 F	1.5	1.3	1.2	1.2	1.4	1.7	2.0	2.3	2.5	2.6	2.5	2.3	2.1	1.9	1.7	1.6	1.6	1.8	2.0	2.1	2.3	2.3	2.2	2.0
5 Sa	1.7	1.5	1.3	1.3	1.3	1.5	1.8	2.1	2.3	2.5	2.6	2.5	2.4	2.1	1.9	1.7	1.6	1.6	1.7	1.9	2.0	2.1	2.1	2.1
6 Su	1.9	1.7	1.6	1.4	1.4	1.4	1.6	1.8	2.1	2.3	2.5	2.6	2.5	2.4	2.2	1.9	1.7	1.6	1.6	1.6	1.8	1.9	2.0	2.1
7 M	2.1	2.0	1.8	1.6	1.5	1.4	1.5	1.6	1.9	2.1	2.4	2.6	2.6	2.6	2.4	2.2	1.9	1.6	1.5	1.4	1.5	1.7	1.9	2.0
8 T	2.1	2.2	2.1	1.9	1.7	1.5	1.4	1.5	1.6	1.8	2.2	2.4	2.6	2.7	2.6	2.4	2.1	1.8	1.5	1.3	1.3	1.4	1.6	1.9
9 W	2.1	2.3	2.3	2.2	2.0	1.7	1.5	1.4	1.4	1.6	1.9	2.2	2.5	2.7	2.8	2.7	2.4	2.0	1.6	1.3	1.1	1.1	1.3	1.6
10 Th	2.0	2.2	2.4	2.4	2.3	2.0	1.7	1.5	1.3	1.3	1.6	1.9	2.3	2.6	2.8	2.8	2.7	2.3	1.8	1.4	1.1	0.9	1.0	1.3
11 F	1.7	2.1	2.4	2.6	2.5	2.3	2.0	1.7	1.4	1.2	1.3	1.6	2.0	2.4	2.7	2.9	2.9	2.6	2.2	1.7	1.2	0.9	0.8	0.9
12 Sa ●	1.3	1.8	2.2	2.5	2.7	2.6	2.3	1.9	1.6	1.3	1.2	1.3	1.7	2.2	2.6	2.9	3.0	2.9	2.5	2.0	1.5	1.0	0.7	0.7
13 Su	0.9	1.4	2.0	2.4	2.7	2.8	2.6	2.3	1.9	1.5	1.2	1.1	1.4	1.8	2.3	2.7	3.0	3.1	2.9	2.4	1.8	1.3	0.8	0.6
14 M	0.6	1.0	1.6	2.1	2.5	2.8	2.8	2.6	2.2	1.8	1.4	1.2	1.2	1.5	2.0	2.5	2.9	3.1	3.0	2.8	2.2	1.6	1.1	0.7
15 T	0.5	0.7	1.1	1.7	2.2	2.6	2.8	2.8	2.6	2.2	1.7	1.4	1.2	1.3	1.6	2.1	2.6	2.9	3.0	2.9	2.6	2.0	1.4	0.9
16 W	0.6	0.5	0.8	1.3	1.9	2.4	2.7	2.9	2.8	2.5	2.1	1.7	1.4	1.3	1.4	1.7	2.2	2.6	2.8	2.9	2.8	2.4	1.8	1.3
17 Th	0.9	0.6	0.7	1.0	1.5	2.0	2.5	2.8	2.9	2.8	2.5	2.1	1.7	1.4	1.3	1.5	1.8	2.2	2.5	2.7	2.7	2.6	2.2	1.7
18 F	1.2	0.9	0.7	0.8	1.2	1.7	2.1	2.5	2.8	2.9	2.8	2.5	2.1	1.8	1.5	1.4	1.5	1.8	2.1	2.4	2.5	2.5	2.4	2.0
19 Sa	1.6	1.3	1.0	0.9	1.0	1.4	1.8	2.2	2.6	2.8	2.9	2.7	2.4	2.1	1.8	1.5	1.4	1.5	1.7	2.0	2.2	2.4	2.4	2.2
20 Su	1.9	1.6	1.4	1.2	1.1	1.2	1.5	1.9	2.3	2.6	2.8	2.8	2.7	2.4	2.1	1.8	1.5	1.4	1.5	1.6	1.8	2.1	2.2	2.3
21 M	2.2	2.0	1.7	1.5	1.3	1.3	1.4	1.6	1.9	2.3	2.6	2.8	2.8	2.7	2.4	2.1	1.8	1.5	1.3	1.3	1.5	1.7	1.9	2.1
22 T	2.2	2.2	2.1	1.9	1.7	1.5	1.4	1.4	1.6	1.9	2.2	2.5	2.7	2.8	2.6	2.4	2.0	1.7	1.4	1.2	1.2	1.3	1.6	1.9
23 W	2.1	2.3	2.3	2.2	2.0	1.8	1.6	1.4	1.4	1.6	1.9	2.2	2.5	2.7	2.8	2.6	2.3	2.0	1.6	1.3	1.1	1.0	1.2	1.6
24 Th	1.9	2.2	2.4	2.5	2.4	2.1	1.8	1.6	1.4	1.4	1.6	1.9	2.3	2.6	2.7	2.8	2.6	2.3	1.8	1.4	1.1	0.9	0.9	1.2
25 F	1.6	2.0	2.3	2.5	2.6	2.4	2.1	1.8	1.5	1.4	1.3	1.6	1.9	2.3	2.6	2.8	2.8	2.6	2.1	1.7	1.3	1.0	0.8	0.9
26 Sa	1.3	1.7	2.1	2.5	2.6	2.6	2.4	2.1	1.7	1.4	1.3	1.4	1.7	2.1	2.5	2.7	2.9	2.8	2.5	2.0	1.5	1.1	0.8	0.7
27 Su ○	1.0	1.4	1.9	2.3	2.6	2.7	2.6	2.3	1.9	1.6	1.4	1.3	1.4	1.8	2.2	2.6	2.8	2.9	2.7	2.3	1.8	1.3	0.9	0.7
28 M	0.8	1.1	1.6	2.1	2.4	2.6	2.7	2.5	2.2	1.8	1.5	1.3	1.3	1.6	2.0	2.4	2.7	2.9	2.8	2.5	2.1	1.5	1.1	0.8
29 T	0.7	0.9	1.3	1.8	2.2	2.5	2.7	2.6	2.4	2.0	1.6	1.4	1.3	1.4	1.8	2.2	2.6	2.8	2.9	2.7	2.3	1.8	1.3	0.9
30 W	0.7	0.8	1.1	1.6	2.1	2.4	2.6	2.7	2.5	2.2	1.8	1.5	1.3	1.3	1.6	1.9	2.3	2.7	2.8	2.7	2.5	2.0	1.5	1.1

LUMUT, PERAK DARUL RIDZUAN

YEAR 2010

Lat 04 14 N   Long 100 37 E

TIME ZONE -0800 — JULY — HEIGHTS IN METRES

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1 Th	0.9	0.8	1.0	1.4	1.9	2.3	2.6	2.7	2.7	2.4	2.1	1.7	1.5	1.3	1.4	1.7	2.1	2.4	2.6	2.7	2.5	2.2	1.8	1.3
2 F	1.0	0.9	0.9	1.2	1.7	2.1	2.4	2.7	2.7	2.6	2.3	1.9	1.6	1.4	1.4	1.5	1.8	2.2	2.4	2.6	2.5	2.3	1.9	1.6
3 Sa	1.2	1.0	1.0	1.2	1.5	1.9	2.3	2.6	2.7	2.7	2.5	2.2	1.9	1.6	1.4	1.4	1.6	1.9	2.2	2.3	2.4	2.3	2.1	1.8
4 Su	1.5	1.2	1.1	1.2	1.4	1.7	2.1	2.4	2.6	2.7	2.6	2.4	2.1	1.8	1.6	1.5	1.5	1.7	1.9	2.1	2.2	2.3	2.2	2.0
5 M	1.7	1.5	1.3	1.3	1.3	1.6	1.9	2.2	2.4	2.6	2.6	2.5	2.3	2.0	1.8	1.6	1.5	1.5	1.6	1.8	2.0	2.1	2.1	2.1
6 T	1.9	1.7	1.6	1.4	1.4	1.5	1.7	1.9	2.2	2.4	2.5	2.5	2.4	2.3	2.0	1.8	1.6	1.5	1.5	1.5	1.7	1.9	2.0	2.1
7 W	2.1	2.0	1.9	1.7	1.6	1.5	1.5	1.6	1.9	2.1	2.3	2.5	2.5	2.5	2.3	2.0	1.8	1.5	1.4	1.3	1.4	1.6	1.8	2.0
8 Th	2.2	2.2	2.2	2.0	1.8	1.6	1.5	1.5	1.6	1.8	2.1	2.3	2.5	2.6	2.5	2.3	2.0	1.7	1.4	1.2	1.2	1.3	1.5	1.8
9 F	2.1	2.3	2.4	2.3	2.1	1.9	1.6	1.5	1.4	1.5	1.7	2.0	2.3	2.6	2.7	2.6	2.4	2.0	1.6	1.3	1.0	1.0	1.1	1.4
10 Sa	1.8	2.2	2.4	2.5	2.5	2.2	1.9	1.6	1.4	1.3	1.4	1.7	2.1	2.5	2.7	2.8	2.7	2.4	1.9	1.5	1.1	0.8	0.8	1.0
11 Su	1.5	1.9	2.3	2.6	2.7	2.6	2.3	1.9	1.5	1.2	1.2	1.3	1.8	2.2	2.6	2.9	3.0	2.8	2.4	1.8	1.3	0.8	0.6	0.6
12 M ●	1.0	1.5	2.1	2.5	2.8	2.8	2.6	2.2	1.8	1.4	1.2	1.1	1.4	1.9	2.4	2.8	3.1	3.1	2.8	2.3	1.6	1.1	0.6	0.4
13 T	0.5	1.0	1.7	2.2	2.6	2.9	2.9	2.7	2.2	1.7	1.3	1.1	1.1	1.5	2.0	2.5	2.9	3.1	3.1	2.7	2.1	1.4	0.9	0.5
14 W	0.3	0.6	1.2	1.8	2.4	2.8	3.0	3.0	2.6	2.1	1.6	1.3	1.1	1.2	1.6	2.1	2.6	3.0	3.1	2.9	2.5	1.9	1.2	0.7
15 Th	0.4	0.4	0.8	1.4	2.0	2.6	2.9	3.1	2.9	2.5	2.0	1.6	1.2	1.1	1.3	1.7	2.2	2.6	2.9	3.0	2.7	2.2	1.6	1.1
16 F	0.7	0.5	0.6	1.1	1.7	2.2	2.7	3.0	3.1	2.8	2.4	1.9	1.5	1.2	1.1	1.4	1.8	2.2	2.6	2.8	2.8	2.5	2.0	1.5
17 Sa	1.0	0.7	0.6	0.9	1.4	1.9	2.4	2.8	3.0	3.0	2.7	2.3	1.8	1.5	1.2	1.2	1.5	1.8	2.2	2.5	2.6	2.5	2.2	1.8
18 Su	1.4	1.1	0.9	0.9	1.2	1.6	2.1	2.5	2.8	2.9	2.8	2.5	2.1	1.8	1.5	1.3	1.3	1.5	1.8	2.1	2.3	2.4	2.3	2.1
19 M	1.8	1.5	1.3	1.2	1.2	1.5	1.8	2.2	2.5	2.7	2.7	2.6	2.4	2.0	1.7	1.5	1.3	1.4	1.5	1.7	1.9	2.1	2.2	2.2
20 T	2.0	1.9	1.7	1.5	1.4	1.4	1.6	1.9	2.1	2.4	2.5	2.6	2.5	2.3	2.0	1.8	1.5	1.4	1.3	1.4	1.6	1.8	2.0	2.1
21 W	2.1	2.1	2.0	1.8	1.7	1.6	1.6	1.6	1.8	2.0	2.2	2.4	2.5	2.4	2.3	2.0	1.8	1.5	1.4	1.3	1.3	1.5	1.7	1.9
22 Th	2.1	2.2	2.3	2.2	2.0	1.8	1.7	1.6	1.6	1.7	1.9	2.1	2.3	2.5	2.5	2.3	2.1	1.8	1.5	1.3	1.1	1.2	1.4	1.6
23 F	1.9	2.2	2.4	2.4	2.3	2.1	1.8	1.6	1.5	1.4	1.6	1.8	2.1	2.4	2.5	2.5	2.4	2.1	1.7	1.4	1.1	1.0	1.1	1.3
24 Sa	1.7	2.0	2.3	2.5	2.5	2.4	2.1	1.8	1.5	1.3	1.3	1.6	1.9	2.2	2.5	2.6	2.6	2.4	2.0	1.6	1.2	1.0	0.8	1.0
25 Su	1.4	1.8	2.2	2.5	2.6	2.6	2.3	2.0	1.6	1.4	1.2	1.3	1.6	2.0	2.4	2.7	2.8	2.6	2.3	1.8	1.4	1.0	0.8	0.8
26 M ○	1.1	1.5	2.0	2.4	2.6	2.7	2.5	2.2	1.8	1.5	1.3	1.2	1.4	1.8	2.3	2.6	2.8	2.8	2.6	2.1	1.6	1.1	0.8	0.7
27 T	0.8	1.2	1.8	2.2	2.6	2.7	2.7	2.4	2.0	1.6	1.3	1.2	1.2	1.6	2.1	2.5	2.8	2.9	2.7	2.4	1.8	1.3	0.9	0.7
28 W	0.7	1.0	1.5	2.0	2.4	2.7	2.8	2.6	2.2	1.8	1.4	1.2	1.2	1.4	1.8	2.3	2.7	2.9	2.8	2.6	2.1	1.6	1.1	0.8
29 Th	0.6	0.8	1.3	1.8	2.3	2.6	2.8	2.8	2.5	2.0	1.6	1.3	1.1	1.2	1.6	2.0	2.5	2.7	2.8	2.7	2.3	1.8	1.3	0.9
30 F	0.7	0.7	1.1	1.6	2.1	2.5	2.8	2.8	2.6	2.2	1.8	1.4	1.2	1.1	1.4	1.8	2.2	2.5	2.7	2.7	2.5	2.0	1.5	1.1
31 Sa	0.8	0.8	1.0	1.4	2.0	2.4	2.7	2.8	2.8	2.4	2.0	1.6	1.3	1.1	1.2	1.5	1.9	2.3	2.5	2.6	2.5	2.2	1.7	1.3

TIME ZONE -0800 — AUGUST — HEIGHTS IN METRES

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1 Su	1.0	0.9	1.0	1.3	1.8	2.2	2.6	2.8	2.8	2.6	2.2	1.8	1.5	1.2	1.2	1.3	1.7	2.0	2.3	2.5	2.5	2.3	1.9	1.6
2 M	1.3	1.1	1.0	1.2	1.6	2.0	2.4	2.6	2.7	2.6	2.4	2.0	1.7	1.4	1.3	1.3	1.5	1.8	2.1	2.3	2.4	2.3	2.1	1.8
3 T	1.5	1.3	1.2	1.2	1.5	1.8	2.1	2.4	2.5	2.6	2.4	2.2	1.9	1.6	1.4	1.3	1.4	1.6	1.8	2.0	2.2	2.2	2.2	2.0
4 W	1.8	1.6	1.4	1.4	1.4	1.6	1.9	2.1	2.3	2.4	2.4	2.3	2.1	1.9	1.7	1.5	1.4	1.4	1.6	1.7	1.9	2.1	2.1	2.1
5 Th	2.0	1.9	1.7	1.6	1.5	1.5	1.6	1.8	2.0	2.2	2.3	2.3	2.3	2.2	2.0	1.7	1.5	1.4	1.4	1.4	1.6	1.8	2.0	2.1
6 F	2.2	2.1	2.1	1.9	1.7	1.6	1.5	1.5	1.7	1.9	2.1	2.2	2.4	2.4	2.3	2.1	1.8	1.6	1.4	1.2	1.2	1.4	1.6	1.9
7 Sa	2.1	2.3	2.3	2.3	2.1	1.8	1.6	1.4	1.4	1.5	1.7	2.0	2.3	2.5	2.6	2.5	2.2	1.8	1.5	1.2	1.0	1.0	1.2	1.6
8 Su	2.0	2.3	2.5	2.6	2.5	2.2	1.8	1.5	1.3	1.2	1.4	1.7	2.1	2.5	2.7	2.8	2.6	2.2	1.8	1.3	0.9	0.7	0.8	1.1
9 M	1.6	2.1	2.5	2.7	2.8	2.6	2.2	1.8	1.4	1.1	1.1	1.3	1.8	2.3	2.7	2.9	2.9	2.7	2.2	1.6	1.1	0.7	0.5	0.6
10 T ●	1.1	1.7	2.3	2.7	2.9	3.0	2.7	2.2	1.7	1.3	1.0	1.0	1.3	1.9	2.5	2.9	3.1	3.0	2.7	2.1	1.4	0.8	0.4	0.3
11 W	0.6	1.2	1.9	2.5	2.9	3.1	3.0	2.7	2.1	1.5	1.1	0.9	1.0	1.4	2.1	2.6	3.0	3.1	3.0	2.5	1.9	1.2	0.6	0.3
12 Th	0.3	0.7	1.4	2.1	2.7	3.1	3.2	3.0	2.5	1.9	1.4	1.0	0.8	1.1	1.6	2.2	2.7	3.0	3.1	2.9	2.3	1.6	1.0	0.5
13 F	0.3	0.5	1.0	1.7	2.4	2.9	3.2	3.2	2.9	2.3	1.7	1.2	0.9	0.9	1.2	1.7	2.3	2.7	2.9	2.9	2.6	2.1	1.4	0.9
14 Sa	0.5	0.5	0.8	1.4	2.0	2.6	3.0	3.2	3.0	2.6	2.1	1.6	1.1	0.9	1.0	1.3	1.8	2.3	2.6	2.8	2.7	2.3	1.8	1.3
15 Su	0.9	0.7	0.8	1.2	1.7	2.2	2.7	2.9	3.0	2.8	2.4	1.9	1.4	1.1	1.0	1.1	1.5	1.9	2.3	2.5	2.6	2.4	2.1	1.7
16 M	1.3	1.1	1.0	1.1	1.5	1.9	2.3	2.6	2.8	2.8	2.5	2.1	1.7	1.4	1.2	1.1	1.3	1.6	1.9	2.2	2.3	2.4	2.2	2.0
17 T	1.7	1.5	1.3	1.3	1.4	1.7	2.0	2.3	2.5	2.6	2.5	2.2	2.0	1.7	1.4	1.3	1.3	1.4	1.6	1.8	2.0	2.1	2.2	2.1
18 W	2.0	1.8	1.7	1.6	1.5	1.6	1.8	2.0	2.2	2.3	2.3	2.3	2.1	1.9	1.7	1.5	1.4	1.4	1.4	1.6	1.7	1.9	2.0	2.1
19 Th	2.1	2.1	2.0	1.9	1.8	1.7	1.7	1.7	1.8	2.0	2.1	2.2	2.2	2.1	2.0	1.8	1.7	1.5	1.4	1.4	1.4	1.6	1.8	2.0
20 F	2.1	2.2	2.3	2.2	2.0	1.9	1.7	1.6	1.6	1.6	1.8	2.0	2.1	2.2	2.2	2.1	1.9	1.7	1.5	1.3	1.2	1.3	1.5	1.8
21 Sa	2.0	2.3	2.4	2.4	2.3	2.1	1.8	1.6	1.4	1.4	1.5	1.7	2.0	2.2	2.4	2.4	2.2	2.0	1.7	1.4	1.1	1.1	1.2	1.5
22 Su	1.8	2.2	2.4	2.6	2.5	2.3	2.0	1.7	1.4	1.3	1.3	1.5	1.8	2.2	2.4	2.6	2.5	2.2	1.9	1.5	1.2	0.9	0.9	1.2
23 M	1.6	2.0	2.4	2.6	2.7	2.6	2.2	1.9	1.5	1.2	1.1	1.3	1.6	2.1	2.4	2.6	2.7	2.5	2.1	1.7	1.2	0.9	0.8	0.9
24 T	1.3	1.8	2.2	2.6	2.8	2.7	2.5	2.1	1.6	1.3	1.1	1.1	1.4	1.9	2.3	2.6	2.8	2.7	2.4	1.9	1.4	1.0	0.7	0.7
25 W ○	1.0	1.5	2.1	2.5	2.8	2.9	2.7	2.3	1.8	1.4	1.1	1.0	1.2	1.7	2.2	2.6	2.8	2.8	2.6	2.2	1.6	1.1	0.8	0.6
26 Th	0.8	1.3	1.8	2.4	2.7	2.9	2.8	2.5	2.0	1.6	1.2	1.0	1.0	1.4	1.9	2.4	2.7	2.9	2.8	2.4	1.9	1.3	0.9	0.7
27 F	0.7	1.1	1.6	2.2	2.6	2.9	2.9	2.7	2.2	1.7	1.3	1.0	0.9	1.2	1.6	2.2	2.6	2.8	2.8	2.6	2.1	1.6	1.1	0.8
28 Sa	0.7	0.9	1.4	2.0	2.5	2.8	3.0	2.8	2.5	1.9	1.5	1.1	0.9	1.0	1.4	1.9	2.3	2.6	2.8	2.7	2.3	1.8	1.3	1.0
29 Su	0.8	0.9	1.3	1.8	2.3	2.7	2.9	2.9	2.6	2.2	1.7	1.2	1.0	0.9	1.2	1.6	2.1	2.4	2.6	2.6	2.4	2.0	1.6	1.2
30 M	1.0	0.9	1.1	1.6	2.1	2.5	2.8	2.8	2.7	2.3	1.9	1.4	1.1	1.0	1.1	1.4	1.8	2.2	2.4	2.6	2.5	2.2	1.8	1.4
31 T	1.2	1.1	1.1	1.5	1.9	2.3	2.6	2.7	2.7	2.4	2.0	1.7	1.3	1.1	1.1	1.2	1.6	1.9	2.2	2.4	2 4	2.3	2.0	1.7

LUMUT, PERAK DARUL RIDZUAN

YEAR 2010

Lat 04 14 N   Long 100 37 E

TIME ZONE -0800

SEPTEMBER

HEIGHTS IN METRES

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1 W	1.4	1.3	1.2	1.4	1.7	2.0	2.3	2.5	2.6	2.5	2.2	1.9	1.6	1.3	1.2	1.2	1.4	1.7	2.0	2.2	2.3	2.3	2.1	1.9
2 Th	1.7	1.5	1.4	1.4	1.6	1.8	2.0	2.2	2.3	2.4	2.3	2.1	1.8	1.6	1.4	1.3	1.4	1.5	1.7	1.9	2.0	2.2	2.2	2.1
3 F	2.0	1.9	1.7	1.6	1.6	1.6	1.7	1.9	2.0	2.2	2.2	2.2	2.1	2.0	1.8	1.6	1.4	1.4	1.4	1.5	1.7	1.9	2.1	2.2
4 Sa	2.2	2.2	2.1	1.9	1.8	1.6	1.6	1.6	1.7	1.9	2.1	2.2	2.3	2.3	2.1	1.9	1.7	1.5	1.3	1.2	1.3	1.5	1.8	2.1
5 Su	2.3	2.4	2.4	2.3	2.1	1.8	1.6	1.4	1.4	1.5	1.8	2.0	2.3	2.5	2.5	2.3	2.1	1.7	1.3	1.1	1.0	1.0	1.3	1.8
6 M	2.2	2.5	2.7	2.7	2.5	2.2	1.8	1.5	1.2	1.2	1.4	1.7	2.1	2.5	2.7	2.7	2.5	2.1	1.6	1.1	0.8	0.7	0.8	1.3
7 T	1.8	2.4	2.7	3.0	2.9	2.6	2.2	1.7	1.3	1.0	1.0	1.3	1.8	2.3	2.7	2.9	2.9	2.5	2.0	1.4	0.9	0.6	0.5	0.8
8 W ●	1.4	2.0	2.6	3.0	3.2	3.1	2.6	2.1	1.5	1.1	0.8	0.9	1.4	2.0	2.5	2.9	3.1	2.9	2.5	1.8	1.2	0.7	0.4	0.4
9 Th	0.9	1.6	2.3	2.8	3.2	3.3	3.1	2.5	1.9	1.3	0.9	0.7	0.9	1.5	2.1	2.7	3.0	3.1	2.9	2.3	1.6	1.0	0.5	0.3
10 F	0.5	1.1	1.9	2.5	3.0	3.3	3.3	2.9	2.3	1.6	1.1	0.7	0.7	1.0	1.7	2.3	2.8	3.0	3.0	2.7	2.1	1.5	0.9	0.5
11 Sa	0.4	0.8	1.5	2.2	2.8	3.1	3.3	3.1	2.6	2.0	1.4	0.9	0.6	0.7	1.2	1.8	2.4	2.8	2.9	2.9	2.5	1.9	1.3	0.9
12 Su	0.6	0.7	1.2	1.8	2.4	2.9	3.1	3.1	2.8	2.3	1.7	1.2	0.8	0.7	0.9	1.4	2.0	2.4	2.7	2.8	2.6	2.2	1.7	1.3
13 M	1.0	0.9	1.1	1.6	2.1	2.5	2.8	3.0	2.8	2.5	2.0	1.5	1.1	0.9	0.9	1.2	1.6	2.0	2.4	2.6	2.6	2.4	2.0	1.7
14 T	1.4	1.2	1.2	1.4	1.8	2.2	2.5	2.7	2.7	2.5	2.1	1.7	1.4	1.1	1.0	1.1	1.4	1.7	2.0	2.3	2.4	2.4	2.2	2.0
15 W	1.7	1.5	1.4	1.5	1.7	2.0	2.2	2.4	2.4	2.4	2.2	1.9	1.7	1.4	1.3	1.2	1.3	1.6	1.8	2.0	2.1	2.2	2.2	2.1
16 Th	2.0	1.9	1.7	1.7	1.7	1.8	1.9	2.0	2.1	2.2	2.1	2.0	1.9	1.7	1.6	1.5	1.4	1.5	1.6	1.7	1.9	2.0	2.1	2.2
17 F	2.2	2.1	2.0	1.9	1.8	1.8	1.7	1.8	1.8	1.9	2.0	2.0	2.0	2.0	1.9	1.7	1.6	1.5	1.5	1.5	1.6	1.8	1.9	2.1
18 Sa	2.3	2.3	2.3	2.2	2.0	1.9	1.7	1.6	1.5	1.6	1.8	1.9	2.1	2.1	2.1	2.0	1.9	1.7	1.5	1.4	1.4	1.5	1.7	2.0
19 Su	2.2	2.4	2.5	2.5	2.3	2.0	1.8	1.5	1.4	1.4	1.5	1.8	2.0	2.2	2.3	2.3	2.1	1.9	1.6	1.3	1.2	1.2	1.4	1.8
20 M	2.1	2.4	2.6	2.7	2.5	2.3	1.9	1.6	1.3	1.2	1.3	1.6	1.9	2.2	2.4	2.5	2.4	2.1	1.7	1.4	1.1	1.0	1.1	1.5
21 T	1.9	2.3	2.6	2.8	2.8	2.5	2.1	1.7	1.3	1.1	1.1	1.3	1.7	2.1	2.5	2.6	2.6	2.3	1.9	1.5	1.2	0.9	0.9	1.2
22 W	1.7	2.2	2.6	2.8	2.9	2.7	2.3	1.9	1.4	1.1	1.0	1.1	1.5	2.0	2.4	2.7	2.7	2.6	2.2	1.7	1.3	0.9	0.8	1.0
23 Th ○	1.4	2.0	2.5	2.8	3.0	2.9	2.6	2.1	1.6	1.2	0.9	0.9	1.3	1.8	2.3	2.8	2.8	2.8	2.4	1.9	1.4	1.0	0.8	0.8
24 F	1.2	1.7	2.3	2.7	3.0	3.0	2.8	2.3	1.7	1.3	0.9	0.8	1.0	1.5	2.0	2.5	2.8	2.8	2.6	2.2	1.7	1.2	0.9	0.8
25 Sa	1.0	1.5	2.1	2.6	2.9	3.1	2.9	2.5	2.0	1.4	1.0	0.8	0.8	1.2	1.8	2.3	2.6	2.8	2.8	2.4	1.9	1.5	1.1	0.9
26 Su	0.9	1.3	1.8	2.4	2.8	3.0	3.0	2.7	2.2	1.6	1.2	0.8	0.7	1.0	1.5	2.0	2.4	2.7	2.8	2.6	2.2	1.7	1.3	1.0
27 M	0.9	1.1	1.6	2.2	2.6	2.9	3.0	2.8	2.4	1.8	1.4	1.0	0.8	0.8	1.2	1.7	2.2	2.5	2.7	2.6	2.4	1.9	1.5	1.2
28 T	1.0	1.1	1.4	1.9	2.4	2.7	2.9	2.8	2.5	2.1	1.6	1.2	0.9	0.9	1.1	1.5	2.0	2.3	2.5	2.6	2.5	2.1	1.8	1.5
29 W	1.2	1.2	1.3	1.7	2.1	2.5	2.7	2.7	2.6	2.3	1.8	1.4	1.1	1.0	1.0	1.3	1.7	2.1	2.3	2.5	2.5	2.3	2.0	1.7
30 Th	1.5	1 3	1.4	1.6	1.9	2.2	2.4	2.6	2.5	2.4	2.0	1.7	1.4	1.2	1.1	1.2	1.5	1.8	2.1	2.3	2.4	2.4	2.2	2.0

TIME ZONE -0800

OCTOBER

HEIGHTS IN METRES

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1 F	1.8	1.6	1.5	1.5	1.7	1.9	2.1	2.3	2.4	2.3	2.2	2.0	1.7	1.5	1.3	1.3	1.4	1.5	1.8	2.0	2.2	2.3	2.3	2.2
2 Sa	2.1	2.0	1.8	1.7	1.7	1.7	1.8	2.0	2.1	2.2	2.2	2.2	2.0	1.8	1.7	1.5	1.4	1.4	1.4	1.6	1.8	2.1	2.3	2.4
3 Su	2.4	2.3	2.2	2.0	1.8	1.7	1.6	1.6	1.7	1.9	2.1	2.2	2.3	2.2	2.0	1.8	1.6	1.3	1.2	1.2	1.4	1.7	2.0	2.3
4 M	2.6	2.7	2.6	2.4	2.2	1.8	1.6	1.4	1.4	1.5	1.8	2.1	2.3	2.5	2.4	2.2	1.9	1.5	1.2	1.0	1.0	1.2	1.6	2.1
5 T	2.5	2.8	2.9	2.9	2.6	2.2	1.7	1.4	1.2	1.2	1.4	1.8	2.2	2.5	2.7	2.6	2.3	1.9	1.4	1.0	0.8	0.8	1.1	1.7
6 W	2.2	2.7	3.0	3.2	3.0	2.6	2.1	1.5	1.1	0.9	1.0	1.4	1.9	2.4	2.7	2.8	2.7	2.3	1.8	1.3	0.8	0.6	0.7	1.2
7 Th	1.8	2.5	3.0	3.3	3.3	3.0	2.5	1.8	1.3	0.9	0.7	0.9	1.5	2.1	2.6	2.9	3.0	2.8	2.3	1.7	1.1	0.7	0.6	0.8
8 F ●	1.4	2.1	2.7	3.2	3.4	3.3	2.9	2.2	1.6	1.0	0.7	0.6	1.0	1.6	2.2	2.7	3.0	3.0	2.7	2.1	1.5	1.0	0.7	0.6
9 Sa	1.0	1.6	2.3	2.9	3.3	3.4	3.2	2.6	1.9	1.3	0.8	0.5	0.6	1.1	1.8	2.4	2.8	3.0	2.9	2.6	2.0	1.4	1.0	0.7
10 Su	0.8	1.3	1.9	2.6	3.0	3.3	3.2	2.9	2.3	1.6	1.1	0.7	0.5	0.8	1.3	1.9	2.5	2.8	2.9	2.8	2.4	1.8	1.4	1.0
11 M	0.9	1.1	1.6	2.2	2.7	3.0	3.1	3.0	2.5	1.9	1.4	0.9	0.7	0.7	1.0	1.6	2.1	2.5	2.7	2.8	2.6	2.2	1.8	1.4
12 T	1.2	1.1	1.4	1.9	2.4	2.7	2.9	2.9	2.6	2.2	1.7	1.2	0.9	0.8	0.9	1.3	1.8	2.2	2.5	2.6	2.6	2.4	2.0	1.7
13 W	1.5	1.3	1.4	1.7	2.1	2.4	2.6	2.7	2.6	2.3	1.9	1.5	1.2	1.0	1.0	1.2	1.6	1.9	2.2	2.4	2.5	2.4	2.2	2.0
14 Th	1.8	1.6	1.6	1.6	1.9	2.1	2.3	2.4	2.4	2.3	2.0	1.7	1.5	1.3	1.2	1.3	1.4	1.7	1.9	2.1	2.3	2.4	2.3	2.2
15 F	2.0	1.9	1.8	1.7	1.8	1.9	2.0	2.1	2.2	2.2	2.1	1.9	1.7	1.6	1.5	1.4	1.4	1.6	1.7	1.9	2.1	2.2	2.3	2.3
16 Sa	2.3	2.2	2.0	1.9	1.8	1.8	1.8	1.8	1.9	2.0	2.0	2.0	1.9	1.8	1.7	1.6	1.5	1.5	1.6	1.7	1.8	2.0	2.2	2.3
17 Su	2.4	2.4	2.3	2.2	2.0	1.8	1.7	1.6	1.6	1.7	1.9	2.0	2.0	2.1	2.0	1.9	1.7	1.6	1.5	1.5	1.6	1.8	2.0	2.3
18 M	2.5	2.6	2.6	2.4	2.2	1.9	1.7	1.5	1.4	1.5	1.7	1.9	2.1	2.2	2.2	2.1	1.9	1.7	1.5	1.4	1.4	1.5	1.8	2.1
19 T	2.4	2.7	2.7	2.7	2.4	2.1	1.7	1.4	1.3	1.3	1.4	1.7	2.0	2.2	2.4	2.3	2.2	1.9	1.6	1.3	1.2	1.3	1.5	1.9
20 W	2.3	2.6	2.8	2.9	2.7	2.3	1.9	1.5	1.2	1.1	1.2	1.5	1.9	2.2	2.4	2.5	2.4	2.1	1.8	1.4	1.2	1.1	1.3	1.7
21 Th	2.1	2.5	2.8	3.0	2.9	2.6	2.1	1.6	1.2	1.0	1.0	1.2	1.7	2.1	2.4	2.6	2.6	2.4	2.0	1.6	1.2	1.0	1.1	1.4
22 F ○	1.9	2.4	2.8	3.0	3.0	2.8	2.3	1.8	1.3	1.0	0.8	1.0	1.4	1.9	2.3	2.6	2.7	2.6	2.3	1.8	1.4	1.1	1.0	1.2
23 Sa	1.6	2.1	2.6	2.9	3.1	3.0	2.6	2.0	1.5	1.0	0.8	0.8	1.1	1.6	2.1	2.5	2.8	2.8	2.5	2.1	1.6	1.2	1.0	1.0
24 Su	1.4	1.9	2.4	2.8	3.1	3.1	2.8	2.3	1.7	1.2	0.8	0.7	0.9	1.3	1.9	2.4	2.7	2.8	2.7	2.3	1.9	1.4	1.1	1.0
25 M	1.2	1.6	2.2	2.6	3.0	3.1	2.9	2.5	1.9	1.4	0.9	0.7	0.7	1.1	1.6	2.1	2.5	2.7	2.8	2.5	2.1	1.7	1.3	1.1
26 T	1.1	1.4	1.9	2.4	2.8	3.0	3.0	2.7	2.2	1.6	1.2	0.8	0.7	0.9	1.3	1.8	2.3	2.6	2.7	2.6	2.3	1.9	1.6	1.3
27 W	1.2	1.3	1.7	2.2	2.6	2.8	2.9	2.8	2.4	1.9	1.4	1.0	0.8	0.8	1.1	1.6	2.0	2.4	2.6	2.7	2.5	2.2	1.8	1.5
28 Th	1.3	1.3	1.5	1.9	2.3	2.6	2.8	2.8	2.6	2.2	1.7	1.3	1.0	0.9	1.0	1.3	1.7	2.1	2.4	2.6	2.6	2.4	2.1	1.8
29 F	1.6	1.4	1.5	1.7	2.0	2.3	2.5	2.6	2.6	2.3	2.0	1.6	1.3	1.1	1.0	1.2	1.5	1.8	2.1	2.4	2.5	2.5	2.4	2.1
30 Sa	1.9	1.7	1.6	1.6	1.8	2.0	2.2	2.4	2.4	2.4	2.2	1.9	1.6	1.4	1.2	1.2	1.3	1.5	1.8	2.1	2.3	2.5	2.5	2.4
31 Su	2.3	2.1	1.9	1.7	1.7	1.7	1.9	2.0	2.2	2.3	2.3	2.2	2.0	1.7	1.5	1.3	1.2	1.3	1.5	1.7	2.0	2.3	2.5	2.6

LUMUT, PERAK DARUL RIDZUAN

YEAR 2010 Lat 04 14 N Long 100 37 E

TIME ZONE -0800

NOVEMBER

HEIGHTS IN METRES

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1 M	2.6	2.5	2.3	2.0	1.8	1.6	1.6	1.7	1.8	2.0	2.2	2.2	2.2	2.1	1.9	1.6	1.4	1.2	1.2	1.3	1.6	2.0	2.3	2.6
2 T	2.8	2.8	2.7	2.4	2.1	1.7	1.5	1.4	1.4	1.6	1.9	2.1	2.3	2.4	2.3	2.0	1.7	1.4	1.2	1.1	1.2	1.5	2.0	2.4
3 W	2.8	3.0	3.0	2.8	2.4	2.0	1.6	1.3	1.1	1.2	1.5	1.9	2.2	2.5	2.5	2.4	2.1	1.7	1.3	1.1	1.0	1.1	1.5	2.1
4 Th	2.6	3.0	3.2	3.1	2.8	2.4	1.8	1.3	1.0	0.9	1.1	1.5	2.0	2.4	2.6	2.7	2.5	2.1	1.7	1.3	1.0	0.9	1.1	1.6
5 F	2.2	2.8	3.1	3.3	3.2	2.7	2.2	1.6	1.1	0.8	0.7	1.0	1.6	2.1	2.5	2.8	2.8	2.6	2.1	1.6	1.2	0.9	0.9	1.2
6 Sa ●	1.8	2.4	2.9	3.2	3.3	3.1	2.5	1.9	1.3	0.8	0.6	0.7	1.1	1.7	2.2	2.7	2.9	2.9	2.5	2.0	1.5	1.1	0.9	1.0
7 Su	1.4	2.0	2.6	3.0	3.2	3.2	2.9	2.3	1.6	1.0	0.6	0.5	0.7	1.3	1.9	2.4	2.7	2.9	2.8	2.4	1.9	1.5	1.1	1.0
8 M	1.2	1.7	2.2	2.7	3.1	3.2	3.0	2.6	2.0	1.4	0.9	0.6	0.5	0.9	1.5	2.0	2.5	2.8	2.9	2.7	2.3	1.8	1.4	1.2
9 T	1.1	1.4	1.9	2.4	2.8	3.0	3.0	2.8	2.2	1.7	1.2	0.8	0.6	0.7	1.2	1.7	2.2	2.5	2.7	2.7	2.5	2.1	1.8	1.4
10 W	1.3	1.3	1.7	2.1	2.5	2.8	2.9	2.8	2.4	2.0	1.5	1.1	0.8	0.7	1.0	1.4	1.9	2.3	2.5	2.7	2.6	2.3	2.0	1.7
11 Th	1.5	1.4	1.5	1.8	2.2	2.5	2.7	2.7	2.5	2.2	1.7	1.4	1.1	0.9	1.0	1.3	1.6	2.0	2.3	2.5	2.6	2.5	2.2	2.0
12 F	1.7	1.6	1.6	1.7	2.0	2.2	2.4	2.5	2.4	2.2	1.9	1.6	1.3	1.2	1.1	1.2	1.5	1.8	2.1	2.3	2.5	2.5	2.4	2.2
13 Sa	2.0	1.8	1.7	1.7	1.8	2.0	2.1	2.3	2.3	2.2	2.0	1.8	1.6	1.4	1.3	1.3	1.4	1.6	1.9	2.1	2.3	2.4	2.5	2.4
14 Su	2.2	2.1	1.9	1.8	1.7	1.8	1.9	2.0	2.1	2.1	2.1	1.9	1.8	1.6	1.5	1.4	1.4	1.5	1.7	1.9	2.1	2.3	2.5	2.5
15 M	2.4	2.3	2.1	2.0	1.8	1.7	1.7	1.7	1.8	1.9	2.0	2.0	2.0	1.9	1.7	1.6	1.5	1.5	1.5	1.7	1.9	2.1	2.4	2.5
16 T	2.6	2.5	2.4	2.2	1.9	1.7	1.6	1.5	1.5	1.7	1.8	2.0	2.0	2.1	2.0	1.8	1.7	1.5	1.5	1.5	1.6	1.9	2.2	2.4
17 W	2.6	2.7	2.6	2.4	2.1	1.8	1.5	1.4	1.3	1.4	1.6	1.9	2.1	2.2	2.2	2.1	1.9	1.7	1.5	1.4	1.4	1.6	1.9	2.3
18 Th	2.6	2.8	2.8	2.7	2.4	2.0	1.6	1.3	1.2	1.2	1.4	1.7	2.0	2.2	2.3	2.3	2.2	1.9	1.6	1.4	1.3	1.4	1.7	2.0
19 F	2.4	2.7	2.9	2.8	2.6	2.2	1.8	1.4	1.1	1.0	1.1	1.4	1.8	2.2	2.4	2.5	2.4	2.2	1.8	1.5	1.3	1.2	1.4	1.8
20 Sa	2.2	2.6	2.8	3.0	2.8	2.5	2.0	1.5	1.1	0.9	0.8	1.1	1.6	2.0	2.4	2.6	2.6	2.4	2.1	1.7	1.4	1.2	1.2	1.5
21 Su ○	1.9	2.4	2.7	3.0	3.0	2.7	2.2	1.7	1.2	0.9	0.7	0.8	1.2	1.7	2.2	2.5	2.7	2.6	2.4	2.0	1.6	1.3	1.1	1.3
22 M	1.6	2.1	2.6	2.9	3.0	2.9	2.5	2.0	1.4	1.0	0.7	0.6	0.9	1.4	2.0	2.4	2.7	2.8	2.6	2.2	1.8	1.4	1.2	1.1
23 T	1.4	1.9	2.3	2.7	3.0	3.0	2.8	2.3	1.7	1.2	0.8	0.6	0.7	1.1	1.6	2.1	2.5	2.7	2.7	2.5	2.1	1.7	1.3	1.2
24 W	1.2	1.6	2.1	2.5	2.9	3.0	3.0	2.6	2.1	1.5	1.0	0.7	0.6	0.8	1.3	1.8	2.3	2.6	2.8	2.7	2.4	2.0	1.6	1.3
25 Th	1.2	1.4	1.8	2.2	2.6	2.9	3.0	2.8	2.4	1.8	1.3	0.9	0.6	0.7	1.0	1.5	2.0	2.4	2.7	2.7	2.6	2.3	1.9	1.6
26 F	1.3	1.3	1.5	1.9	2.3	2.7	2.8	2.8	2.6	2.1	1.6	1.2	0.8	0.7	0.8	1.2	1.7	2.1	2.5	2.7	2.7	2.5	2.2	1.9
27 Sa	1.6	1.4	1.4	1.7	2.0	2.3	2.6	2.7	2.6	2.4	1.9	1.5	1.1	0.9	0.8	1.0	1.4	1.8	2.2	2.5	2.7	2.7	2.5	2.2
28 Su	1.9	1.7	1.5	1.5	1.7	2.0	2.2	2.4	2.5	2.4	2.2	1.8	1.5	1.2	1.0	0.9	1.1	1.5	1.9	2.2	2.5	2.7	2.7	2.6
29 M	2.3	2.0	1.8	1.6	1.6	1.7	1.9	2.1	2.2	2.3	2.3	2.1	1.8	1.5	1.3	1.1	1.1	1.2	1.5	1.9	2.3	2.5	2.7	2.8
30 T	2.7	2.4	2.1	1.8	1.6	1.5	1.5	1.7	1.9	2.1	2.2	2.2	2.1	1.9	1.6	1.4	1.2	1.2	1.3	1.5	1.9	2.3	2.6	2.8

TIME ZONE -0800

DECEMBER

HEIGHTS IN METRES

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1 W	2.9	2.7	2.5	2.2	1.8	1.5	1.4	1.3	1.5	1.7	1.9	2.1	2.2	2.2	2.0	1.8	1.5	1.3	1.2	1.3	1.5	1.9	2.3	2.6
2 Th	2.9	2.9	2.8	2.5	2.1	1.7	1.4	1.2	1.1	1.3	1.6	1.9	2.2	2.3	2.3	2.2	1.9	1.6	1.3	1.2	1.2	1.5	1.9	2.3
3 F	2.7	2.9	3.0	2.8	2.5	2.0	1.6	1.2	0.9	0.9	1.2	1.5	1.9	2.3	2.5	2.5	2.3	2.0	1.6	1.3	1.2	1.2	1.5	1.9
4 Sa	2.4	2.8	3.0	3.0	2.8	2.4	1.8	1.3	0.9	0.7	0.8	1.1	1.6	2.1	2.4	2.6	2.6	2.4	2.0	1.6	1.3	1.1	1.2	1.5
5 Su	2.0	2.5	2.8	3.0	3.0	2.7	2.2	1.6	1.1	0.7	0.6	0.7	1.2	1.7	2.2	2.5	2.7	2.7	2.4	2.0	1.6	1.3	1.1	1.2
6 M ●	1.6	2.1	2.6	2.9	3.0	2.9	2.5	2.0	1.4	0.9	0.6	0.5	0.8	1.3	1.9	2.3	2.6	2.8	2.7	2.3	1.9	1.5	1.2	1.1
7 T	1.4	1.8	2.3	2.7	3.0	3.0	2.8	2.3	1.7	1.2	0.8	0.5	0.6	1.0	1.5	2.0	2.4	2.7	2.8	2.6	2.2	1.8	1.4	1.2
8 W	1.2	1.5	2.0	2.4	2.8	2.9	2.9	2.6	2.0	1.5	1.0	0.7	0.5	0.7	1.2	1.7	2.2	2.5	2.7	2.7	2.4	2.1	1.7	1.4
9 Th	1.3	1.4	1.7	2.2	2.5	2.8	2.9	2.7	2.3	1.8	1.3	0.9	0.7	0.7	1.0	1.5	1.9	2.3	2.6	2.7	2.6	2.3	1.9	1.6
10 F	1.4	1.3	1.5	1.9	2.3	2.6	2.7	2.7	2.4	2.0	1.5	1.1	0.9	0.7	0.9	1.3	1.7	2.1	2.4	2.6	2.6	2.4	2.1	1.8
11 Sa	1.6	1.4	1.4	1.7	2.0	2.3	2.5	2.6	2.5	2.2	1.8	1.4	1.1	0.9	0.9	1.1	1.5	1.9	2.3	2.5	2.6	2.6	2.3	2.0
12 Su	1.8	1.6	1.5	1.6	1.8	2.0	2.3	2.4	2.4	2.2	1.9	1.6	1.3	1.1	1.0	1.1	1.4	1.7	2.1	2.4	2.5	2.6	2.5	2.3
13 M	2.0	1.8	1.6	1.5	1.6	1.8	2.0	2.1	2.2	2.2	2.0	1.8	1.5	1.3	1.2	1.2	1.3	1.6	1.9	2.2	2.4	2.5	2.6	2.4
14 T	2.2	2.0	1.8	1.6	1.6	1.6	1.7	1.9	2.0	2.1	2.0	1.9	1.7	1.6	1.4	1.3	1.3	1.5	1.7	1.9	2.2	2.4	2.5	2.5
15 W	2.4	2.2	2.0	1.8	1.6	1.5	1.5	1.6	1.7	1.9	1.9	2.0	1.9	1.8	1.7	1.5	1.4	1.4	1.5	1.7	1.9	2.2	2.4	2.5
16 Th	2.5	2.4	2.3	2.0	1.8	1.5	1.4	1.4	1.5	1.6	1.8	1.9	2.0	2.0	1.9	1.8	1.6	1.5	1.5	1.5	1.7	1.9	2.2	2.4
17 F	2.5	2.6	2.5	2.2	2.0	1.7	1.4	1.2	1.2	1.3	1.6	1.8	2.0	2.1	2.1	2.1	1.9	1.7	1.5	1.4	1.5	1.6	1.9	2.2
18 Sa	2.4	2.6	2.6	2.5	2.2	1.8	1.5	1.2	1.0	1.1	1.3	1.6	1.9	2.1	2.3	2.3	2.2	1.9	1.7	1.5	1.3	1.4	1.6	1.9
19 Su	2.3	2.5	2.7	2.7	2.5	2.1	1.7	1.3	1.0	0.9	0.9	1.3	1.7	2.0	2.3	2.5	2.4	2.2	1.9	1.6	1.4	1.2	1.3	1.6
20 M ○	2.0	2.4	2.7	2.8	2.7	2.4	2.0	1.5	1.1	0.8	0.7	0.9	1.3	1.8	2.2	2.5	2.6	2.5	2.2	1.8	1.5	1.2	1.2	1.3
21 T	1.7	2.2	2.6	2.8	2.9	2.7	2.3	1.8	1.2	0.8	0.6	0.6	0.9	1.5	2.0	2.4	2.6	2.7	2.5	2.1	1.7	1.4	1.1	1.1
22 W	1.4	1.9	2.4	2.8	3.0	3.0	2.7	2.1	1.5	1.0	0.6	0.4	0.6	1.1	1.6	2.1	2.5	2.7	2.7	2.5	2.0	1.6	1.2	1.1
23 Th	1.2	1.6	2.1	2.6	2.9	3.0	2.9	2.5	1.9	1.3	0.8	0.4	0.4	0.7	1.2	1.8	2.3	2.7	2.8	2.7	2.4	1.9	1.5	1.2
24 F	1.1	1.3	1.7	2.2	2.7	2.9	3.0	2.8	2.3	1.7	1.1	0.6	0.4	0.4	0.8	1.4	2.0	2.5	2.8	2.9	2.7	2.3	1.9	1.4
25 Sa	1.2	1.1	1.4	1.8	2.3	2.7	2.9	2.9	2.6	2.0	1.5	0.9	0.6	0.4	0.6	1.1	1.7	2.2	2.6	2.8	2.9	2.6	2.2	1.8
26 Su	1.4	1.2	1.2	1.5	1.9	2.3	2.6	2.8	2.7	2.3	1.8	1.3	0.9	0.6	0.5	0.8	1.3	1.9	2.3	2.7	2.9	2.8	2.5	2.2
27 M	1.8	1.5	1.3	1.3	1.6	1.9	2.3	2.5	2.6	2.4	2.1	1.6	1.2	0.9	0.7	0.8	1.1	1.5	2.0	2.4	2.7	2.8	2.8	2.5
28 T	2.1	1.8	1.5	1.3	1.4	1.6	1.9	2.1	2.3	2.3	2.2	1.9	1.6	1.3	1.0	0.9	1.0	1.3	1.7	2.1	2.5	2.7	2.8	2.7
29 W	2.4	2.1	1.8	1.5	1.3	1.4	1.5	1.7	1.9	2.1	2.2	2.1	1.9	1.7	1.4	1.2	1.1	1.2	1.4	1.8	2.1	2.4	2.6	2.7
30 Th	2.6	2.4	2.1	1.8	1.5	1.3	1.3	1.4	1.5	1.7	1.9	2.1	2.1	2.0	1.8	1.6	1.4	1.3	1.3	1.5	1.7	2.0	2.3	2.5
31 F	2.6	2.6	2.4	2.1	1.8	1.5	1.2	1.1	1.2	1.4	1.6	1.9	2.0	2.1	2.1	2.0	1.8	1.6	1.4	1.4	1.4	1.7	2.0	2.3

Appendix E: The numbering and pre weight for each of the test coupons.

CHINA	ID	Weight before Exposed(gram)				Weight after Exposed(gram)				
Frame 7		1	2	3	Average	1	2	3	4	Average
Atmospheric Zone	0	30.31	30.31	30.31	30.31					
	1	30.3	30.3	30.3	30.3					
	2	30.85	30.85	30.85	30.85					
	4	30.36	30.36	30.36	30.36					
Splash zone	0	64.99	64.99	64.99	64.99					
	1	63.51	63.51	63.51	63.51					
	2	66.61	66.61	66.61	66.61					
	3	63.67	63.67	63.67	63.67					
Fully Immersed	5	31.98	31.98	31.98	31.98					
	6	31	31	31	31					
	7	31.69	31.69	31.69	31.69					
	10	31.95	31.95	31.95	31.95					
Frame 8										
Atmospheric Zone	11	32.05	32.05	32.05	32.05					
	13									
	14	29.96	29.96	29.96	29.96					
	15	31.4	31.4	31.4	31.4					
Splash zone	4	64.01	64.01	64.01	64.01					

	5	64.04	64.04	64.04	64.04					
	6	63.33	63.33	63.33	63.33					
	7	63.94	63.94	63.94	63.94					
Fully Immersed	16	30.43	30.43	30.43	30.43					
	17	30.75	30.75	30.75	30.75					
	18	32.15	32.15	32.15	32.15					
	19	31.01	31.01	31.01	31.01					
Frame 9										
Atmospheric Zone	20	30.63	30.63	30.63	30.63					
	21	30.71	30.71	30.71	30.71					
	22	32.5	32.5	32.5	32.5					
	23	31.06	31.06	31.06	31.06					
Splash Zone	8	65.22	65.22	65.22	65.22					
	9	64.26	64.26	64.26	64.26					
	10	63.84	63.84	63.84	63.84					
	12	65.03	65.03	65.03	65.03					
Fully Immersed	24	31	31	31	31					
	25	30.51	30.51	30.51	30.51					
	26	32.13	32.13	32.13	32.13					
	27	31.94	31.94	31.94	31.94					
Frame 10										
Atmospheric Zone	28	30.56	30.56	30.56	30.56					
	29	31.85	31.85	31.85	31.85					

	30	32.34	32.34	32.34	32.34					
	31	32.44	32.44	32.44	32.44					
Splash Zone	14	63.44	63.44	63.44	63.44					
	17	64.54	64.54	64.54	64.54					
	18	64.52	64.52	64.52	64.52					
	19	64.85	64.85	64.85	64.85					
Fully Immersed	32	30.62	30.62	30.62	30.62					
	33	30.92	30.92	30.92	30.92					
	34	32.69	32.69	32.69	32.69					
	36	30.7	30.7	30.7	30.7					
Frame 11										
Atmospheric Zone	46	32.44	32.44	32.44	32.44					
	47	30.03	30.03	30.03	30.03					
	48	30.44	30.44	30.44	30.44					
	49	32.12	32.12	32.12	32.12					
Splash Zone	16	64.5	64.5	64.5	64.5					
	20	65.13	65.13	65.13	65.13					
	25	65.38	65.38	65.38	65.38					
	30	63.99	63.99	63.99	63.99					
Fully Immersed	37	32.79	32.79	32.79	32.79					
	38	30.76	30.76	30.76	30.76					
	39	30.53	30.53	30.53	30.53					
	40	31.59	31.59	31.59	31.59					

Frame 12										
Atmospheric Zone	55	31.08	31.08	31.08	31.08					
	56	30.88	30.88	30.88	30.88					
	57	32.36	32.36	32.36	32.36					
	58	32.02	32.02	32.02	32.02					
Splash Zone	26	65.64	65.64	65.64	65.64					
	27	65.98	65.98	65.98	65.98					
	28	65.91	65.91	65.91	65.91					
	29	64.11	64.11	64.11	64.11					
Fully Immersed	50	32.76	32.76	32.76	32.76					
	51	31.84	31.84	31.84	31.84					
	53	30.9	30.9	30.9	30.9					
	54	31.57	31.57	31.57	31.57					
Frame 13										
Atmospheric Zone	63	30.57	30.57	30.57	30.57					
	64	31.98	31.98	31.98	31.98					
	65	31.26	31.26	31.26	31.26					
	66	32.41	32.41	32.41	32.41					
Splash Zone	24	65.42	65.42	65.42	65.42					
	41	64.05	64.05	64.05	64.05					
	42	63.59	63.59	63.59	63.59					
	43	64.44	64.44	64.44	64.44					
Fully Immersed	59	31.22	31.22	31.22	31.22					
	60	31.32	31.32	31.32	31.32					

	61	32.07	32.07	32.07	32.07					
	62	31.17	31.17	31.17	31.17					
Frame 14										
Atmospheric Zone	67	32.2	32.2	32.2	32.2					
	68	31.63	31.63	31.63	31.63					
	69	31.77	31.77	31.77	31.77					
	70	30.84	30.84	30.84	30.84					
Splash Zone	33	64.53	64.53	64.53	64.53					
	34	65.14	65.14	65.14	65.14					
	35	65.13	65.13	65.13	65.13					
	36	64.38	64.38	64.38	64.38					
Fully Immersed	71	30.4	30.4	30.4	30.4					
	72	31.48	31.48	31.48	31.48					
	73	31.68	31.68	31.68	31.68					
	74	30.94	30.94	30.94	30.94					
Frame 15										
Atmospheric Zone	79	30.81	30.81	30.81	30.81					
	80	31.64	31.64	31.64	31.64					
	81	30.53	30.53	30.53	30.53					
	82	31.75	31.75	31.75	31.75					
Splash Zone	21	64.58	64.58	64.58	64.58					
	22	64.45	64.45	64.45	64.45					
	23	64.54	64.54	64.54	64.54					

	31	65.48	65.48	65.48	65.48					
Fully Immersed	75	32.05	32.05	32.05	32.05					
	77	31.46	31.46	31.46	31.46					
	78	31.8	31.8	31.8	31.8					
Frame 16										
Atmospheric Zone	88	32.35	32.35	32.35	32.35					
	89	31.65	31.65	31.65	31.65					
	90	30.29	30.29	30.29	30.29					
	91	32.21	32.21	32.21	32.21					
Splash Zone	37	65.29	65.29	65.29	65.29					
	38	64.47	64.47	64.47	64.47					
	39	65.88	65.88	65.88	65.88					
	40	65.13	65.13	65.13	65.13					
Fully Immersed	83	31.84	31.84	31.84	31.84					
	84	32.16	32.16	32.16	32.16					
	87	31.06	31.06	31.06	31.06					
Frame 17										
Atmospheric Zone	96	31.77	31.77	31.77	31.77					
	97	31.25	31.25	31.25	31.25					
	98	31.25	31.25	31.25	31.25					
	99	32.42	32.42	32.42	32.42					
Splash Zone	44	66.5	66.5	66.5	66.5					
	45	65.32	65.32	65.32	65.32					

	46	64.07	64.07	64.07	64.07					
Fully Immersed	92	32.32	32.32	32.32	32.32					
	93	30.53	30.53	30.53	30.53					
	95	30.99	30.99	30.99	30.99					
Frame 18										
Atmospheric Zone	76	32.45	32.45	32.45	32.45					
	86	32.08	32.08	32.08	32.08					
	94	30.35	30.35	30.35	30.35					
Splash Zone	47	65.45	65.45	65.45	65.45					
	49	67.3	67.3	67.3	67.3					
	50	65.1	65.1	65.1	65.1					
Fully Immersed	35									
	36	30.7	30.7	30.7	30.7					
	44	34.79	34.79	34.79	34.79					

JAPAN	ID	Weight before Exposed(gram)				Weight after Exposed(gram)				
Frame 1		1	2	3	Average	1	2	3	4	Average
Atmospheric Zone	1	51.72	51.72	51.72	51.72					
	2	50.62	50.62	50.62	50.62					
	3	48.77	48.77	48.77	48.77					
	4	51.98	51.98	51.98	51.98					
Splash zone	1	106.18	106.18	106.18	106.18					
	2	107.34	107.34	107.34	107.34					
	3	106.89	106.89	106.89	106.89					
	4	106.46	106.46	106.46	106.46					
Fully Immersed	5	48.49	48.49	48.49	48.49					
	6	50.13	50.13	50.13	50.13					
	7	49.71	49.71	49.71	49.71					
	8	50.85	50.85	50.85	50.85					
Frame 2										
Atmospheric Zone	37	49.87	49.87	49.87	49.87					
	38	49.64	49.64	49.64	49.64					

	39	50.9	50.9	50.9	50.9					
	40	50.56	50.56	50.56	50.56					
Splash zone	21	107.17	107.17	107.17	107.17					
	22	106.92	106.92	106.92	106.92					
	23	106.53	106.53	106.53	106.53					
	24	106.34	106.34	106.34	106.34					
Fully Immersed	29	48.01	48.01	48.01	48.01					
	30	51.06	51.06	51.06	51.06					
	31	49.85	49.85	49.85	49.85					
	32	50.19	50.19	50.19	50.19					
Frame 3										
Atmospheric Zone	9	49.87	49.87	49.87	49.87					
	10	49.95	49.95	49.95	49.95					
	11	49.02	49.02	49.02	49.02					
	12	50.39	50.39	50.39	50.39					
Splash zone	9	106.26	106.26	106.26	106.26					
	10	107.03	107.03	107.03	107.03					
	11	106.39	106.39	106.39	106.39					
	12	106.13	106.13	106.13	106.13					

Fully Immersed	25	51.22	51.22	51.22	51.22					
	26	51.46	51.46	51.46	51.46					
	27	48.74	48.74	48.74	48.74					
	28	50.38	50.38	50.38	50.38					
Frame 4										
Atmospheric Zone	45	50.4	50.4	50.4	50.4					
	46	50.78	50.78	50.78	50.78					
	47	50.5	50.5	50.5	50.5					
	48	50.25	50.25	50.25	50.25					
Splash zone	5	107.56	107.56	107.56	107.56					
	6	106.66	106.66	106.66	106.66					
	7	107.23	107.23	107.23	107.23					
	8	107.13	107.13	107.13	107.13					
Fully Immersed	13	50.87	50.87	50.87	50.87					
	14	47.26	47.26	47.26	47.26					
	15	50.69	50.69	50.69	50.69					
	16	50.83	50.83	50.83	50.83					
Frame 5										

Atmospheric Zone	33	52.03	52.03	52.03	52.03					
	34	47.87	47.87	47.87	47.87					
	42	49.95	49.95	49.95	49.95					
	43	51.62	51.62	51.62	51.62					
Splash zone	17	106.89	106.89	106.89	106.89					
	18	105.99	105.99	105.99	105.99					
	19	106	106	106	106					
	20	107.04	107.04	107.04	107.04					
Fully Immersed	17	49.44	49.44	49.44	49.44					
	18	48.22	48.22	48.22	48.22					
	19	48.54	48.54	48.54	48.54					
	20	49.5	49.5	49.5	49.5					
Frame 6										
Atmospheric Zone	35	47.85	47.85	47.85	47.85					
	36	50.89	50.89	50.89	50.89					
	41	51.25	51.25	51.25	51.25					
	44	49.46	49.46	49.46	49.46					
Splash zone	13	107.29	107.29	107.29	107.29					
	14	107.01	107.01	107.01	107.01					

	15	106.24	106.24	106.24	106.24					
	16	105.88	105.88	105.88	105.88					
Fully Immersed	21	50.61	50.61	50.61	50.61					
	22	49.19	49.19	49.19	49.19					
	23	50.44	50.44	50.44	50.44					
	24	50.25	50.25	50.25	50.25					